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RESEARCH AIRCRAFT SUPPORT AND DATA ANALYSIS FOR THE HEART, SAMS--ETC(U)  
MAR 76 C CULLIAN, S STEINBERG  
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# RESEARCH AIRCRAFT SUPPORT AND DATA ANALYSIS FOR THE HEART, SAMS, AND FLAME PROGRAMS

Meteorology Research , Inc.  
464 West Woodbury Road  
Altadena, California 91001

4 March 1976

Final Report

CONTRACT No. DNA 001-75-C-0040

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| Support of HEART, SAMS, and FLAME, hydrometeor sampling programs at Wallops Island, Virginia during 1975 and 1976 fiscal years under the direction of DNA and AFCRL. Included was modifying a Cessna Citation jet aircraft with the installation of all air-borne sampling instrumentation, operating the aircraft, and reducing the data obtained. |                       |   |  |

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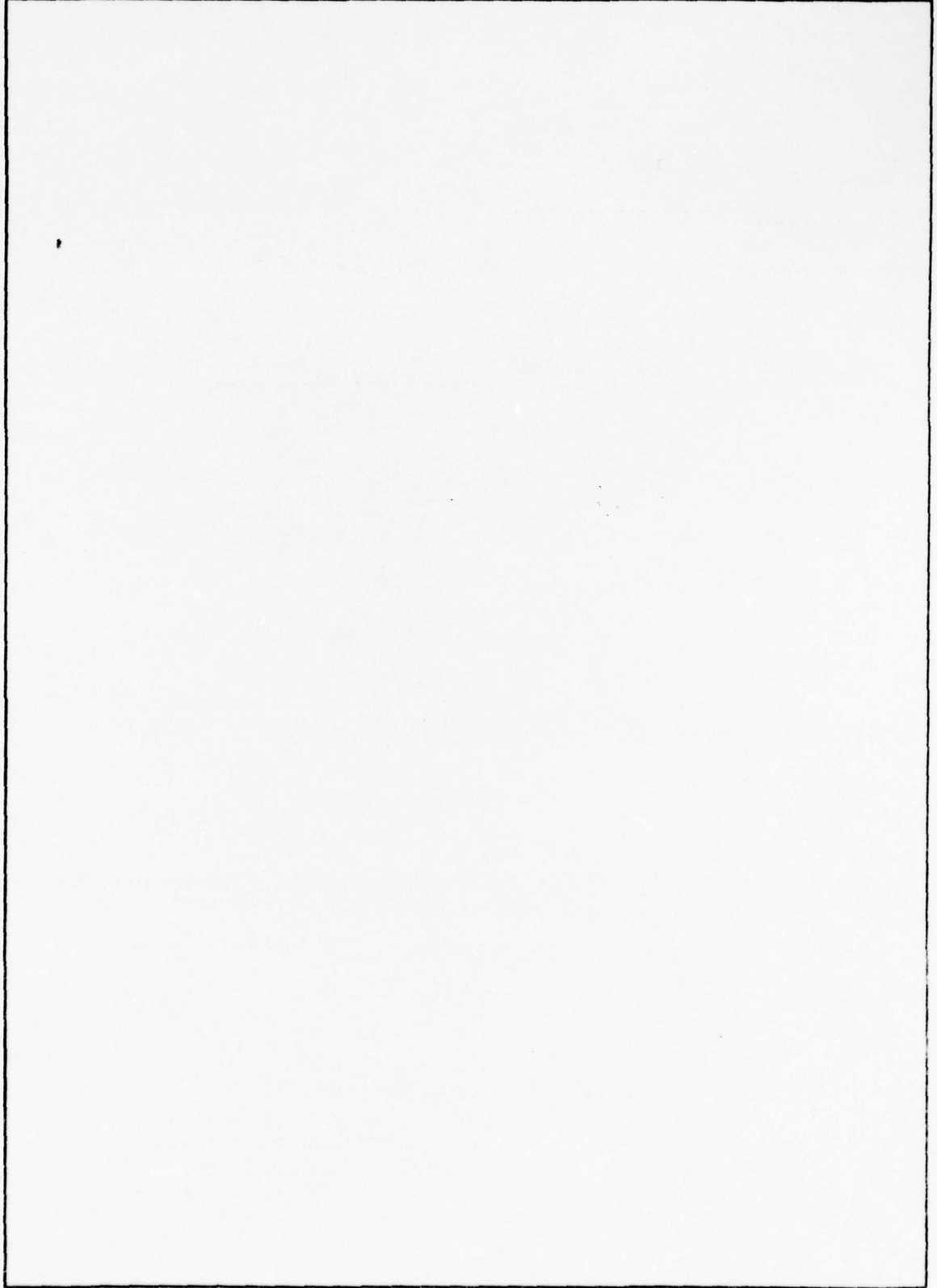
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# TABLE OF CONTENTS

|   | Page |
|---|------|
| 1. INTRODUCTION                                       | 3    |
| 2. LEASE CITATION N511CC                              | 4    |
| 3. CITATION CREW AND AIRCRAFT SUPPORT                 | 6    |
| 4. DATA ANALYSIS                                      | 8    |
| 5. LEASE OF LITTON LTN-51 INERTIAL NAVIGATION SYSTEMS | 10   |
| 6. INS NAVIGATION SYSTEM FOR HEART AND FLAME PROGRAMS | 12   |
| 7. INSTALLATION OF SAI HOLOGRAPHIC CAMERA             | 13   |

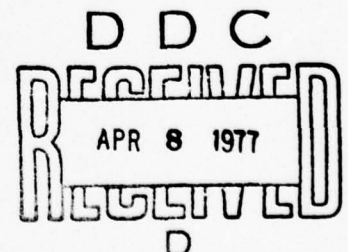
## SUPPLEMENT NO. 1 - BIMONTHLY PROGRESS REPORTS

|  |       |
|--|-------|
| 1-1 Bimonthly Report No. 1, 13 January 1975      | 1-1.1 |
| 1-2 Bimonthly Report No. 2, 15 February 1975     | 1-2.1 |
| 1-3 Bimonthly Report MRI 75R-1327, 15 April 1975 | 1-3.1 |
| 1-4 Bimonthly Report No. 4, June 1975            | 1-4.1 |

## SUPPLEMENT NO. 2 - DATA SUMMARIES

|   |       |
|---|-------|
| 2-1 Data Summary MRI 75R-1325, 4 April 1975     | 2-1.1 |
| 2-2 Data Summary MRI 75R-1295, 14 February 1975 | 2-2.1 |
| 2-3 Data Summary MRI 75R-1332, 15 May 1975      | 2-3.1 |
| 2-4 Data Summary MRI 75R-1357, 28 August 1975   | 2-4.1 |
| 2-5 Data Summary MRI 75R-1358, 28 August 1975   | 2-5.1 |
| 2-6 Data Summary MRI 75R-1359, 28 August 1975   | 2-6.1 |

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## 1. INTRODUCTION

This document reports the work completed under Contract No. DNA001-75-C-0040 by Meteorology Research, Inc. (MRI) during the fiscal years 1975 and 1976.

MRI supported Defense Nuclear Agency (DNA) and Air Force Cambridge Research Laboratories (AFCRL) in HEART, SAMS, and FLAME hydrometer sampling programs at Wallops Island, Virginia. This support consisted of a leased Cessna Citation jet aircraft specially instrumented and operated by MRI for the testing period. The instrumentation included a programmed INS leased from Litton Aero Products and modified for the HEART sampling missions.

Data analysis consisted of a "Quick-Look" report issued within 72 hours of an operation, preliminary data summaries, and final mission reports.

An additional scientific task was undertaken at the request of AFCRL/DNA. This task involved the review of C-130 and Citation PMS data for the purpose of evaluating the operation of particle size spectrometers. This work is reported in Report No. DNA 3991F.

## 2. LEASE CITATION N511CC

A lease was negotiated with Alpine Aircraft Charters, Inc., Denver, Colorado, guaranteeing exclusive use of Cessna Citation N511CC beginning on 16 November 1974 and terminating on 15 April 1975. An option to extend the lease was included to allow for the possible extension of test operations beyond the scheduled termination date of 31 March 1975. On 26 March 1975, MRI received a TWX from DNA extending the HEART program to allow missile DW8 to be launched through suitable weather. The new program cutoff date was extended to 30 April 1975 and the Citation lease was extended accordingly.

Alpine Aircraft Charters, Inc. maintained the aircraft, avionics, engine, and subsystems and performed all routine maintenance inspections as per the lease agreement. Maintenance work performed on the aircraft was scheduled so as not to impact test operations, and was supervised by the full-time copilot/crew chief provided under the aircraft lease agreement.

Insurance coverage was provided by Alpine Aircraft Charters, Inc. and the cost included in the lease price of the aircraft. Per the DNA contract work statement, the following minimum amounts of insurance was provided:

- a. Aircraft Hull Insurance - full coverage
- b. Bodily Injury, other than passenger liability - \$250,000
- c. Property Damage - \$500,000 per accident
- d. Passenger Liability - \$100,000 per passenger

A copy of the certificate of insurance is included in the Bi-monthly Report dated 13 January 1975, Supplement No. 1-1 Appendix B.

The lease provided for unlimited usage of the aircraft during the period of the agreement. A list of all flights of the Citation is provided in the Bimonthly Reports, see Supplement No. 1.

An MRI program manager maintained close contact with Alpine Aircraft Charters, Inc. to ensure all lease provisions were accomplished and all necessary maintenance was performed on the aircraft. All invoices were examined and flight time charges were verified with any conflicting items being resolved.

### 3. CITATION CREW AND AIRCRAFT SUPPORT

A consulting agreement was negotiated with a Citation rated captain to be available to support all HEART and FLAME operations, associated meetings, briefings, and alerts throughout the deployment period at Wallops Flight Center, Virginia. The Citation captain, copilot/crew chief, and instrument operator were permanently relocated to the vicinity of Wallops Flight Center and remained there for the duration of the program.

The MRI program manager and sensor technician were available on an as-needed basis. The program manager monitored the following:

- a. Activities of the crew.
- b. Status of the Citation aircraft and its instrumentation package.
- c. Procuring and shipping consummable and crew support items as they were needed.
- d. Arranging the replacement of crew members as the need arose.
- e. Closely monitoring the packaging, shipment, and receipt of data.
- f. Handling customer's requests for special services as the need arose.

All consummable supplies, spare parts, and maintenance kits required to operate the Citation aircraft and its sensor package were procured and shipped to Wallops Flight Center and used as needed throughout the program. An MRI program manager was in daily contact with the support crew and any needed supplies or spare parts were shipped as soon as possible. In this way, the aircraft and every part

of the sensing package was available for program support in a 100 percent ready condition almost constantly.

One foil impactor, MRI Model 1220A, and one MRI portable instrument package were provided for the duration of the program.

#### 4. DATA ANALYSIS

Three types of reports analyzing the data were submitted for DNA to AFCRL. A "Quick-Look" report was issued within 72 hours after an operation, reviewing the aircraft and sensor performance. A Preliminary Data Summary was delivered within one week after the operation, which contained estimates of the ice-water content and homogeneity profiles based upon nominal size-mass tables. The final report discussed the results of the replicator tape analysis in detail and contained final size-mass tables, number density spectra and ice-water content homogeneity profiles. The dates these reports were issued are included in the following table. Copies of these reports are included as Supplement No. 2.

# MRI CITATION FLIGHT OPERATIONS AND DATA SUMMARY

| Date<br>(1975) | Operation                     | No. of<br>Missiles<br>Fired | Quick Look<br>Report<br>Issued | Data Tapes<br>and/or                  |   |                         |
|----------------|-------------------------------|-----------------------------|--------------------------------|---------------------------------------|---|-------------------------|
|                |                               |                             |                                | Preliminary<br>Data Summary<br>Issued | Final Mission<br>Data Summary<br>Issued | MRI<br>Report<br>Number |
| 1-9            | SAMS                          | 2                           | 1-9                            | N/A                                   | 4-4-75                                  | MRI 75 R-1325           |
| 1-20           | HEART                         | 1                           | 1-24                           | 2-14-75                               | 2-14-75                                 | MRI 75 R-1295           |
| 2-4            | FLAME                         | 1                           | 2-4                            | N/A                                   | N/A                                     | N/A                     |
| 3-5            | HEART                         | 0                           | N/A                            | N/A                                   | Note 1                                  |                         |
| 3-7            | SAMS                          | 1                           | 3-8                            | N/A                                   | 5-16-75                                 | MRI 75 R-1332           |
| 4-10           | Navajo/Cit.                   | 0                           | 4-14                           | N/A                                   | N/A                                     | N/A                     |
| 4-15           | SAMS                          | 1                           | 4-15                           | N/A                                   | 8-28-75                                 | MRI 75 R-1357           |
| 4-25           | Radar/Navajo/<br>Cit. Correl. | 0                           | N/A                            | N/A                                   | 8-28-75                                 | MRI 75 R-1358           |
| 4-28           | Radar/Navajo/<br>Cit. Correl. | 0                           | N/A                            | N/A                                   | 8-28-75                                 | MRI 75 R-1359           |

Note 1: No holograms were available from SAI for comparison with the Formvar replicator photographs prepared from this mission.

## 5. LEASE OF LITTON LTN-51 INERTIAL NAVIGATION SYSTEMS

A lease agreement was negotiated with Litton Aero Products providing full-time use of two Litton LTN-51 inertial navigational systems for the entire length of the contract period. A semi-annual (six-month) lease was negotiated due to the cost savings compared to a monthly lease for five months. A copy of the lease agreement is included in the Bimonthly Report dated 13 January 1975, in Supplement 1-1, Appendix C.

One INS was installed in the Cessna Citation research aircraft and the other in the Navy P-3A located at Jacksonville, Florida. Included with both LTN-51 systems was a special leased pallet equipped with dual inverters and designed to adapt the INS installation to aircraft such as the Citation and P-3A. In accordance with the lease agreement, Litton Aero Products supplied emergency batteries designed to fit the pallet assemblies which ensured continued INS operation in the event of any temporary electrical power interruption.

The leases provided for insurance against all risks of loss or damage from every cause for full replacement value, as well as public liability including personal injury and property damage.

Field service support by Litton Aero Products was included in the lease and on 1 May 1975, the LTN-51 inertial navigation system, including the INU, CDU, MSU, battery, and pallet assembly, was removed from the Citation aircraft at Cable Airport, Upland, California. The following day, 2 May, it was delivered to Litton in Woodland Hills, California. The INS aboard the Navy P-3A aircraft was removed by Litton field service personnel on 4 and 5 April 1975 in Denver, Colorado.

Both inertial navigation systems were in good condition when received at Litton's factory and letters to this effect are included in the Bimonthly Report dated 15 June 1975, Supplement No. 1-4, Appendix B.

An MRI program manager administered the provisions of the lease agreements, reviewed all invoices, and resolved any conflicting items.

## 6. INS NAVIGATION SYSTEM FOR HEART AND FLAME PROGRAMS

For the HEART and FLAME programs, MRI developed special hardware and software for use with the Litton LTN-51 navigation system. A contract was set up with Litton Aero Products to write special software which would allow the MRI Citation and P-3A aircrafts to "storm-follow" while making their post reentry data sampling runs. When the reentry vehicle reached the pierce point, the mission start switch was activated and the software propagated the coordinate system as the reentry trajectory penetrated the storm. A complete description of the program and its operation is included in Bimonthly Report MRI 75R-1327 dated 15 April 1975, in Supplement No. 1-3.

MRI also developed a display system which accepts the LTN-51 track angle error (TKE) three wire synchro signal and conditions it to drive a control transformer display. The electronics and control transformer comprises an off-the-shelf unit which has been mechanically modified to allow an unambiguous steering command to be displayed in the cockpit.

With the special LTN-51 software, the track error display need only be kept at zero by aircraft steering to bring the aircraft to the desired sampling points. These systems were installed in the MRI Citation and Navy P-3A aircrafts.

A special electronic interface was designed and fabricated by MRI which interrogates the LTN-51 serial data bus and converts it to a parallel BCD format compatible with the Buffer Memory Systems. The unit was installed on the MRI Citation and P-3A aircrafts.

## 7. INSTALLATION OF SAI HOLOGRAPHIC CAMERA

On 24 June 1974, the MRI Citation was issued approval by the Federal Aviation District Office at Teterboro, New Jersey, for the installation of the SAI Holographic camera. This installation included an instrument table inside the aircraft for the cooler, the power supply, and the control electronics. The ruby laser and 70 mm film magazine were bracketed off the interior aircraft structure and a special aluminum plate window was fabricated to accept the transmitting and receiving probes.

A complete set of FAA documents for this installation as well as the engineering documentation and drawings is presented in MRI Bimonthly Report MRI 75R-1327, a copy of which is included in Supplement No. 1-3.

SUPPLEMENT NO. 1

BIMONTHLY PROGRESS REPORTS

- 1-1 Bimonthly Report No. 1, 13 January 1975
- 1-2 Bimonthly Report No. 2, 15 February 1975
- 1-3 Bimonthly Report MRI 75R-1327, 15 April 1975
- 1-4 Bimonthly Report No. 4, 15 June 1975

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SUPPLEMENT 1-1

Research Aircraft Support for  
HEART, SAMS, and FLAME at Wallops Island

1 October 1974 - 15 November 1974

by

Stefan Steinberg

First issued as Bimonthly Report No. 1, 13 January 1975

1-1.1

## TABLE OF CONTENTS

|            |   | Page   |
|------------|---|--------|
| 1.         | INTRODUCTION  | 1-1.3  |
| 2.         | PROGRESS IN PRINCIPAL TASK AREAS                      | 1-1.3  |
| 2.1        | <u>Lease Citation N511CC</u>                          | 1-1.3  |
| 2.1.1      | <u>Lease Agreement</u>                                | 1-1.3  |
| 2.1.2      | <u>Maintenance and Repair of Aircraft Systems</u>     | 1-1.3  |
| 2.1.3      | <u>Copilot/Crew Chief Support</u>                     | 1-1.4  |
| 2.1.4      | <u>Insurance Coverage</u>                             | 1-1.4  |
| 2.1.5      | <u>Aircraft Flying Time</u>                           | 1-1.4  |
| 2.2        | <u>Secure Approval of Lease</u>                       | 1-1.4  |
| 2.3        | <u>Coordination of Field Operations</u>               | 1-1.4  |
| 2.4        | <u>Administer Citation Lease</u>                      | 1-1.5  |
| 2.5        | <u>Lease Litton LTN-51 Inertial Navigation System</u> | 1-1.5  |
| 2.5.1      | <u>Lease Agreement</u>                                | 1-1.5  |
| 2.5.2      | <u>Pallet Assembly</u>                                | 1-1.5  |
| 2.5.3      | <u>Emergency Battery</u>                              | 1-1.5  |
| 2.5.4      | <u>Insurance</u>                                      | 1-1.5  |
| 2.5.5      | <u>Installation and Removal</u>                       | 1-1.6  |
| 2.6        | <u>Administer INS Lease</u>                           | 1-1.6  |
| 2.7        | <u>Flight Crew Transportation and Accommodations</u>  | 1-1.6  |
| 3.         | SUMMARY OF CITATION FLIGHTS                           | 1-1.6  |
| 4.         | ACTIVITIES DURING THE NEXT REPORTING PERIOD           | 1-1.6  |
| APPENDICES |   |        |
| A.         | Lease Agreement With Alpine Aircraft Charters, Inc.   | A1-1.1 |
| B.         | Certificate of Insurance                              | B1-1.1 |
| C.         | Litton LTN-51 INS Lease                               | C1-1.1 |

## 1. INTRODUCTION

This document reports on the progress made under Contract DNA001-75-C-0040. The report covers the period from 1 October 1974 through 30 November 1974.

MRI is supporting DNA and AFCRL in HEART, SAMS and FLAME hydrometeor sampling programs at Wallops Island, Virginia. Part of this support is an MRI instrumented and operated Cessna Citation sampling aircraft leased for the five month test period 16 November 1974 through 15 April 1975. The instrumentation includes an INS leased from Litton Aero Products and modified specifically for HEART sampling missions.

This report discusses the progress of the Citation lease, the INS lease, Citation flight time and flight crew transportation, accommodations and coordination activities.

## 2. PROGRESS IN PRINCIPAL TASK AREAS

### 2.1 Lease Citation N511CC

#### 2.1.1 Lease Agreement

A lease was negotiated with Alpine Aircraft Charters, Inc., Denver, Colorado, guaranteeing exclusive use of Cessna Citation N511CC beginning on 16 November 1974 and terminating on 15 April 1975. An option to extend the lease was included to allow for the possible extension of test operations beyond the presently scheduled termination date of 31 March 1975.

A copy of the lease agreement is included in Appendix A.

#### 2.1.2 Maintenance and Repair of Aircraft Systems

The lease agreement specifies that Alpine Aircraft Charters, Inc. will maintain the aircraft, avionics, engines, and subsystems and perform all

routine maintenance inspections. Maintenance work done on the aircraft will be scheduled so as not to impact test operations.

2.1.3 Copilot/Crew Chief Support

In accordance with the lease agreement, Alpine Aircraft Charters, Inc. will provide a full-time copilot/crew chief to support all operations during the lease period.

2.1.4 Insurance Coverage

Insurance coverage is to be provided by Alpine Aircraft Charters, Inc. and the cost included in the lease price of the aircraft. The insurance coverage will be in the following amounts.

- a. Aircraft Hull Insurance - full coverage
- b. Bodily Injury, other than passenger liability - \$250,000
- c. Property Damage - \$500,000 per accident
- d. Passenger Liability - \$100,000 per passenger

The certificate of insurance is included in Appendix B.

2.1.5 Aircraft Flying Time

The lease provides for unlimited usage of the aircraft during the period of the agreement.

2.2 Secure Approval of Lease

Lease negotiations for securing both the aircraft and copilot/crew chief began October 1, 1974 and were concluded before 16 November 1974. Since this predated the contract award, no formal approval of the lease by DNA was possible. However, all conditions were in accordance with pre-contract discussions.

2.3 Coordination of Field Operations

The MRI program manager is maintaining close contact with DNA and other government agencies to assure full co-ordination of all aircraft operations.

#### 2.4 Administer Citation Lease

The MRI program manager is maintaining close contact with Alpine Aircraft Charters, Inc. to assure all lease provisions are being accomplished and all necessary maintenance is performed on the aircraft. Invoices are examined and flight time charges are verified with any conflicting items being resolved.

#### 2.5 Lease Litton LTN-51 Inertial Navigation System

##### 2.5.1 Lease Agreement

The lease agreement negotiated with Litton Aero Products provides full-time use of a Litton LTN-51 inertial navigation system for the entire length of the contract period. A semi-annual (6 month), lease was negotiated due to the cost savings compared to a five month period on a monthly cost basis.

##### 2.5.2 Pallet Assembly

A special pallet assembly equipped with dual inverters and designed to adopt the Litton LTN-51 installation to aircraft such as the Citation, is included in the lease and has been installed in the Citation.

##### 2.5.3 Emergency Battery

In accordance with the lease agreement Litton Aero Products has supplied an emergency battery designed to fit the pallet assembly which assures continued INS operation in the event of any temporary electrical power interruption.

##### 2.5.4 Insurance

The lease provides for insurance against all risks or loss or damage from every cause for full replacement value as well as public liability including personal injury and property damage.

#### 2.5.5 Installation and Removal

In accordance with the lease, Litton Aero Products is providing field service support for the complete installation, checkout and removal of the INS from the Cessna Citation Aircraft.

#### 2.6 Administer INS Lease

An MRI program manager is administering the provisions of the lease agreement, reviewing all invoices and resolving any conflicting items.

#### 2.7 Flight Crew Transportation and Accommodations

Accommodations have been secured in the vicinity of Wallops Island for the Citation captain, copilot/crew chief, and instrument operator.

### 3. SUMMARY OF CITATION FLIGHTS

|            |           |   |
|------------|-----------|---|
| 1 November | 9.0       | Ferry aircraft from Cessna<br>maintenace facility in Des<br>Moines to Los Angeles |
| 4 November | 0.4       | Flight check  |
| Total time | 9.4 Hours |   |

### 4. ACTIVITIES DURING THE NEXT REPORTING PERIOD

During the period from 16 November 1974 through 15 January 1975 the INS will be flight tested and the aircraft ferried to Wallops Flight Center. The crew will arrive on January 6, 1975 and be available at the request of the program director for support flights.

APPENDIX A  
AIRCRAFT LEASE

A1-1.1

## AIRCRAFT LEASE

This agreement made this 15th day of October 1974 by and between Alpine Aircraft Charters, Inc., 6200 Plateau Drive, Englewood, Colorado, 80110 hereinafter referred to as "Lessor" and Meteorology Research, Inc. hereinafter referred to as "Lessee," is made with reference to the following facts, circumstances, and conditions:

A. Alpine Aircraft Charters, Inc. has available for lease Cessna Citation, Registration No. N511CC equipped as described in Exhibit A, attached hereto, and as so equipped being hereinafter referred to as "the aircraft". During the term of this lease the aircraft will be operated in Restricted Category due to modifications for cloud particle sampling. All modifications for Lessee's equipment will be made at Lessee's expense.

B. Lessee desires to lease the aircraft for use in cirrus cloud characterization studies, and the Lessor is willing to lease the aircraft to the Lessee upon the terms and conditions hereinafter set forth:

1. The Lessor does hereby lease the aircraft to the Lessee for a period of five (5) months, commencing on the day of delivery of the aircraft at Stapleton International Airport, Denver, Colorado or at its then current location, at the option of the Lessee, on 16 November 1974 and terminating on 15 April 1975 with option to extend with reasonable notice to Lessor. The hourly rate and terms for this extension will be negotiated prior to 1 April 1975. Lease of the aircraft to be computed at \$15000. per month plus \$400. per flying hour. This rate covers one crew member (co-pilot/maintenance officer) Lessor's cost for fuel, maintenance and insurance. The rate without fuel will be \$350.00 per hour. Reasonable and proper travel expenses of the Co-Pilot/Maintenance Officer will be paid by Lessee while he is engaged in flight activities for Lessee more than 100 miles from Denver, Colorado. Payment for meals and lodging will not exceed \$25 per day.

2. Lease payments will be due in the amount of \$15,000. on the first day of the month covered by the payment. The number of flying hours flown in each calendar month will be determined by the Lessee. Payment for these flying hours will be due from the Lessee 30 days after receipt of invoice.

3. The aircraft will be delivered by the Lessor and accepted by the Lessee on or about 16 November 1974.

The Lessee shall be permitted to inspect the aircraft prior to acceptance to note any deficiencies of condition or equipment. Prior to acceptance, the Lessor shall correct or make mutually acceptable arrangements concerning any deficiencies so noted.

4. The aircraft will be returned to the Lessor by the Lessee at Lessee's own expense to Stapleton International Airport, Denver, Colorado upon termination of this lease in the same condition as received, reasonable wear and tear excepted.

5. The Lessee, after delivery of said aircraft to him and acceptance by him, shall have exclusive use thereof and said Lessee agrees that he has inspected said aircraft will all equipment thereon as listed in Exhibit A attached hereto, and the aircraft is suitable for the purpose for which it is intended. After the delivery of said aircraft and Lessee's acceptance thereof, the Lessee shall be responsible to the Lessor that said aircraft is kept in first class airworthy condition, and said Lessee undertakes and agrees that said aircraft will not be flown at any time unless it is airworthy and in first class condition.

6. The Lessor, during the term of this lease, shall have the right to make inspections of the aircraft for the purpose of determining the number of hours the aircraft has been flown during any given calendar month, or for the purpose of determining wheather or not the Lessee is complying with the covenants made by the Lessee herein. Such inspections of the aircraft by the Lessor shall be at the Lessor's own expense. Hours of use of the aircraft for the purpose of this lease shall be logged by the recording Hobbs Meter.

7. During the term of this lease, the Lessee shall pay the following operating and maintenance expenses: NONE

The Lessor shall pay all other maintenance expenses and repairs, including 50-and 100-hour inspections, which shall be performed or contracted by

Lessor at Patrick Henry Aiport, Newport News, Virginia, or at a Fixed Base so as not to impact Lessee's operational missions.

Those repairs or replacements required for normal operation of the aircraft shall be first approved by the Lessor or his agent if the cost of repair or replacement exceeds \$500.00.

8. During the term of the Lease, the Lessor shall be liable for any loss or damage to the aircraft, or the death or injury persons and/or damage to any property caused by the operation of the aircraft. Lessor shall obtain insurance as follows:

a. Aircraft Hull Insurance - Certificated indicating coverage by Lessor.

b. Bodily injury other than passenger liability - \$250,000 per person; \$500,00 per accident.

c. Property damage - \$500,00 per accident.

d. Passenger liability - \$100,000 per passenger with an aggregate equal to the total number of seats or passengers, whichever is greater.

9. The Lessee may not assign this lease or any rights thereunder withour prior written consent of Lessor.

10. In addition to the forgoing covenants made by and agreed to be kept by the Lesse, the Lessee does hereby covenant and agree:

a. To keep safely and use carefully the aircraft and not to sell or attempt to sell or assign or dispose of the aircraft or any interest therein, or part thereof, or equipment necessary thereto, or incur any mechanic or other lien in connection with repair or maintenance or storage of the aircraft, or rent the same, without the prior written consent of the Lessor.

b. During the term of this lease and until the redelivery of the aircraft to the Lessor, to abide by and conform to and cause others to abide by and conform to all laws, ordinances, orders, rules, and regulations, national, state, municipal or otherwise, now existing or hereafter enancted,

controlling or in any way affecting the operations, use or occupancy of the aircraft or the use of any airport premises by the aircraft.

c. Not to permit the aircraft to be operated at any time by a person without a pilot's license or by a person with less qualifications than those required by applicable insurance policies covering this aircraft.

11. This lease shall terminate should the Lessee or Lessor be in default of any of the provisions of the lease, and should said Lessee or Lessor fail to remedy such default within thirty (30) days after receipt of notice from the other party to remedy such default. This termination of the lease by reason of default on the part of either party shall be in addition to any other remedies legally available to the parties in question.

12. Any consent or notice required or permitted to be given by this lease shall, in the case of consent or notice by Lessor, be signed by an appropriate officer of Lessor's agent and sent by mail to Lessee at Meteorology Research, Inc., 464 West Woodbury Road, Altadena, California 91001, or to such other address as the Lessee may from time to time designate in writing to Lessor for the purpose, and in the case of consent or notice by Lessee shall be sent by mail to Alpine Aircraft Charters, Inc., Box 7191, Denver, Colorado 80207 or to such other address as the Lessor may from time to time designate in writing to the Lessee for the purpose.

IN WITNESS WHEREOF, the parties hereto have hereunto set their hands and seals the day and year first above written.

Alpine Aircraft Charters, Inc.  
6200 Plateau Drive  
Englewood, Colorado 80110

By \_\_\_\_\_  
J.J. Hernandez, Exec. V.P.  
METEOROLOGY RESEARCH, INC.

By \_\_\_\_\_  
R.D. Wiggins  
Vice Pres. Adm. & Finance

## AIRCRAFT EQUIPMENT

1. All equipment provided as "standard" in the Cessna Citation Series 500 when delivered from the factory is to be included and in operating condition.
2. The instrumentation and avionics will be sufficient to permit operation to CAT II. instrument limits.
3. The cabin interior will be in the passenger configuration except only the two left rear passenger seats will be installed.

APPENDIX B  
CERTIFICATE OF INSURANCE

B1-1.1

# CERTIFICATE OF INSURANCE

Date July 11, 19 74

THIS IS TO CERTIFY that the Insured set forth below is at this date insured with the Company(ies) as indicated under Policy(ies) described in the following schedule.

## DESCRIPTIVE SCHEDULE

Insured: **Alpine Aircraft Charters, Inc., et al**  
 Address of Insured: **6200 Plateau Drive, Englewood, Colorado 80110**  
 Locations Covered: **Western Hemisphere - excluding North Slope \*\*\***  
 Aircraft: **N511CC**

|  | Company                           | Policy No.      | Expiration Date | Limits of Liability                   |
|--|-----------------------------------|-----------------|-----------------|---------------------------------------|
| <b>Aircraft Liability</b>                                  |                                   |                 |                 |                                       |
| Bodily Injury  | <b>Argonaut Insurance Company</b> | <b>H-4-1244</b> | <b>4/18/75</b>  | Each Person \$                        |
| Property Damage  |                                   |                 |                 | Each Occurrence \$                    |
| Passenger  |                                   |                 |                 | Each Occurrence \$                    |
| Single Limit incl. Passenger                               |                                   |                 |                 | Each Person \$                        |
| Single Limit excl. Passenger                               |                                   |                 |                 | Each Occurrence \$                    |
|  |                                   |                 |                 | Each Occurrence \$ <b>5,000,000.*</b> |
| <b>Airport Liability</b>                                   |                                   |                 |                 |                                       |
| Bodily Injury  |                                   |                 |                 | Each Person \$                        |
| Property Damage  |                                   |                 |                 | Each Occurrence \$                    |
| Single Limit   |                                   |                 |                 | Each Accident \$                      |
|  |                                   |                 |                 | Each Accident \$                      |
| <input type="checkbox"/> Hull - Ground only                | <b>Argonaut Insurance Co.</b>     | <b>H-4-1244</b> | <b>4/18/75</b>  | Amount of Insurance                   |
| <input checked="" type="checkbox"/> Hull - Ground & Flight |                                   |                 |                 | <b>\$680,000.00</b>                   |
| Workmen's Compensation                                     |                                   |                 |                 | Statutory                             |

This certificate is issued at the request of Meteorology Research \*\*  
464 West Woodbury Road  
 whose address is Altadena, California

30

Whom we agree, ~~to~~ to notify ~~in~~ days before date of Cancellation, if policy should be cancelled, but the Company(ies) shall not be liable in any way for failure to give such notice.

This certificate of insurance neither affirmatively nor negatively amends, alters or extends the coverage afforded by Policy H-4-1244 issued by Argonaut Insurance Company.

## ADDITIONAL AGREEMENTS

\*Includes \$50,000. Cargo Legal Liability and \$5,000./\$40,000. Baggage Legal Liability.

\*\*Meteorology Research is added as an ☒ Southern Marine & Aviation Underwriter, Inc. additional insured under the above policy ☐ Southern Marine & Aviation, Inc.

\*\*\*Includes one round trip to Kwajalein Atoll Aviation Managers

via Alaska and the Aleutian Islands with atmospheric research in the Wake Islands

area of the Pacific with the contract to end on or about November 15, 1974.

By Bill O. Smith  
 Authorized Representative

APPENDIX C  
LITTON AERO PRODUCTS  
EQUIPMENT LEASE AGREEMENT

C1-1.1

## EQUIPMENT LEASE AGREEMENT

LEASE dated as of the 19th day of October, 1973  
by and between Aero Products Division of Litton Systems, Inc.,  
a corporation organized under the laws of the State of Delaware  
(hereinafter called "Lessor") having a place of business at  
21050 Burbank Boulevard, Woodland Hills, California 91364 and  
Meteorology Research Inc. (hereinafter  
called "Lessee"), having a place of business at 464 West  
Woodbury Road, Altadena, California 91001  
(Street Address, City and State)

### W I T N E S S E T H :

For and in consideration of the mutual covenants and promises  
hereinafter set forth, the parties hereto agree as follows:

1. LEASE: Lessor hereby leases to Lessee and Lessee leases  
from Lessor the equipment described in the Equipment Schedule  
attached hereto and made a part hereof, subject to the terms and  
conditions set forth in said Schedule or Schedules and also set  
forth herein.

2. TERM: The term of this Lease with respect to any item of  
leased Equipment shall be as set forth in the Equipment Schedule  
or Schedules.

3. EQUIPMENT AND RENT: The Equipment leased hereunder, the  
rent payable, the time, place and manner of payment, shall be as  
specified in the Equipment Schedule or Schedules attached hereto  
and made a part hereof.

4. DELIVERY OF EQUIPMENT: The Equipment is to be shipped to  
Lessee at the place and time specified in the attached Equipment  
Schedule or Schedules.

5. INSPECTION BY LESSEE: Lessor shall not be liable for loss  
or damage occasioned by any cause, circumstance or event of whatso-  
ever nature, including but not limited to failure of or delay in  
delivery, delivery to the wrong place, delivery of improper Equip-  
ment or property other than Equipment, damage to Equipment, govern-  
mental regulations, strike, embargo or any other cause, circumstance  
or event, whether of like or unlike nature. Lessee shall inspect  
Equipment within forty-eight (48) hours after its arrival at the  
address set forth in Equipment Schedule. Unless within said forty-  
eight (48) hours Lessee gives written notice to Lessor, specifying  
any defect in or other proper objection to Equipment, Lessee agrees  
that it shall be conclusively presumed, as between Lessor and Lessee,

6/9/71

CI-1.3

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that Lessee has fully inspected Equipment, that Equipment is in full compliance with the terms of this Lease and in good condition and repair, and that Lessee is satisfied with and has accepted Equipment.

6. USE AND MAINTENANCE; ALTERATIONS AND ADDITIONS: Lessee shall use Equipment solely in the conduct of its business, and in a careful and proper manner, and shall not part with possession of or enter into any sub-lease with respect to Equipment or any part thereof or assign this Lease or its interest hereunder without the prior written consent of Lessor. Lessee shall not make any material alterations to Equipment without the prior written consent of Lessor. Unless otherwise agreed to in writing by the parties hereto, Lessee, at its own expense, will install the leased Equipment in the place or places stipulated herein and will also pay directly the charges for the packing, crating, freight, expense or cartage for each unit of Equipment leased hereunder and will reimburse the Lessor forthwith on written notice, if the Lessor is charged for the same and does pay the same.

7. LIABILITY OF LESSOR Lessor shall not be liable for any consequential, incidental, or special damage of any kind (including therein, but not by way of limitation, damages for any loss of or use of profit by Lessee or other, or for any other similar or dissimilar collateral or consequential damages), which may result from or in connection with the manufacture, delivery, installation, checkout or use of the items leased hereunder, or from or in connection with the services rendered by Lessor hereunder.

8. INDEMNITY: Lessee shall indemnify Lessor against and hold Lessor harmless from any and all claims, actions, suits, proceedings, costs, expenses, damages and liabilities, including attorneys' fees, claimed by any person, organization, association or otherwise, arising out of, connected with, or resulting from the Equipment, including without limitation, the design, manufacture, selection, delivery, possession, use, operation and/or return of the Equipment.

\*9. INSURANCE: Lessee shall keep Equipment insured against all risks or loss or damage from every cause whatsoever for not less than the full replacement value (new) thereof and shall carry public liability insurance, both personal injury and property damage, covering Equipment. All said insurance shall be in form and amount and with companies satisfactory to Lessor. All insurance for loss or damage shall provide that losses, if any, shall be payable to

\*This clause does not apply. Insurance of leased equipment will be born by Lessor. Cost of insurance is \$500 per month and is shown as a separate item.

Lessor, and all such liability insurance shall be in the joint names of Lessor and Lessee. Lessee shall pay the premiums therefor and deliver to Lessor the policies of insurance or duplicates thereof, or other evidence satisfactory to Lessor of such insurance coverage. In case of the failure of Lessee to procure or maintain said insurance or to comply with any other provision of this Lease, Lessor shall have the right, but shall not be obligated, to effect such insurance or compliance on behalf of Lessee. In that event, all moneys spent by and expenses of Lessor in effecting such insurance or compliance shall be deemed to be additional rent, and shall be paid by Lessee to Lessor with the next monthly payment of rent.

10. COMPLIANCE WITH LAWS; PAYMENT OF TAXES: Lessee shall keep the Equipment free and clear of all levies, liens and encumbrances and shall pay all license fees, registration fees, assessments, charges, permit fees and taxes (municipal, state and federal) which may now or hereafter be imposed upon the ownership, leasing, renting, possession, sale or use of the Equipment, excluding however, all taxes on or measured by Lessor's income. Lessee shall comply with all laws and regulations relating to the ownership, possession, leasing, renting, operation, control, use, maintenance, delivery and/or return of the Equipment and shall save Lessor harmless against actual or asserted violations and pay all costs and expenses of every character in connection therewith or arising therefrom. The prices specified in the attached Equipment Schedule are quoted F.O.B. Woodland Hills, California, exclusive of all taxes and other levies by governmental authority. If Lessor is required to pay any such taxes, fees, excises and/or charges, Lessee shall promptly reimburse Lessor upon receipt of Lessor's invoice therefor.

11. TITLE OF LESSOR: Title to Equipment shall at all times remain in Lessor, and Lessee at its own cost and expense, shall protect and defend the title of Lessor. Lessee shall at all times keep Equipment free and clear from all levies, attachments, liens, encumbrances and charges or other judicial process of every kind whatsoever, shall give Lessor immediate written notice thereof and shall indemnify and save Lessor harmless from any loss or damages caused thereby.

12. INSPECTION: If Equipment is removed from the aircraft in which it is installed, Lessee shall advise Lessor of its exact location. Lessor shall have the right from time to time to enter upon the Lessee's premises or elsewhere for the purpose of inspection. If the Equipment is in the opinion of Lessor being used beyond its capacity or in any manner improperly cared for or abused, Lessor has the right to remove said Equipment forthwith.

13. DEFAULT; REMEDIES: If (a) Lessee refuses to accept delivery of the Equipment or reneges on his agreement to lease, or (b) Lessee shall default in the payment of any rent or in making any

other payment hereunder when due, or (c) Lessee shall default in the payment when due of any indebtedness of Lessee to Lessor arising independently of this Lease, or (d) Lessee shall default in the performance of any other covenant herein and such default shall continue for five (5) days after written notice thereof to Lessee by Lessor, or (e) Lessee becomes insolvent or makes an assignment for the benefit of creditors, or (f) Lessee applies for or consents to the appointment of a receiver, trustee or liquidator of Lessee or of all or a substantial part of the assets of Lessee, or if such receiver, trustee or liquidator is appointed without the application or consent of Lessee, or (g) a petition is filed by or against Lessee under the Bankruptcy Act or any amendment thereto (including, without limitation, a petition for reorganization, arrangement or extension) or under any other insolvency law or law providing for the relief of debtors, then, if and to the extent permitted by applicable law, Lessor shall have the right to exercise any one or more of the following remedies: (A) to declare the entire amount of unpaid total rent for the balance of the term of this Lease due and payable, whereupon the same shall become immediately due and payable; (B) without demand or legal process, to enter into premises where Equipment may be found and take possession of and remove the same, whereupon all rights of Lessee in Equipment shall terminate absolutely, and retain Equipment and all prior payments of rent made hereunder, it being agreed that the amounts to be retained by Lessor under this sub-section (B) shall not be as a penalty but as liquidated damages for the breach hereof and as reasonable return for the use of Equipment and for the depreciation thereof; (C) to recover the balance of all amounts due hereunder; (D) to pursue any other remedy available to Lessor at law or in equity. The remedies provided under (B) and (C) may be exercised only in the alternative. This Lease is irrevocable for the full term thereof as set forth in the Equipment Schedule and for the aggregate rentals therein reserved and the rent shall not abate by reason of termination of Lessee's right of possession and/or the taking of possession by the Lessor or for any other reason.

14. NO WAIVER: No failure on the part of the Lessor to exercise, and no delay in exercising any right or remedy hereunder shall operate as a waiver thereof; nor shall any single or partial exercise by Lessor of any right or remedy hereunder preclude any other or further exercise thereof.

15. POSSESSION AND USE: Lessor covenants to and with Lessee that Lessor is the lawful owner of Equipment, free from all liens and encumbrances, and that, upon Lessee's paying the rents and performing the promises, terms and conditions hereof, Lessee shall peaceably and quietly hold, possess and use Equipment during the term of this Lease without hindrance.

16. INTEREST AND EXPENSES: Should Lessee fail to pay duly and promptly any part of the rent herein reserved or any other sum required to be paid by Lessee to Lessor hereunder, Lessee shall pay Lessor interest on such delinquent payment at the rate of 1-1/2% or the highest legal rate of interest permitted by law, whichever is lower, per month on the unpaid balance from the date when such payment was due until paid and expenses of collection, including reasonable attorney's fees.

17. NOTICES: All notices relating hereto shall be in writing and shall be deemed properly delivered when duly mailed by first-class mail, postage prepaid, or delivered by hand to the other party, at its address as follows, or to such other address as either party may by written notice designate to the other.

(a) As to Lessor: Litton Systems, Inc.  
Aero Products Division  
21050 Burbank Boulevard  
Woodland Hills, Calif. 91364  
Attention: Contracts Manager

(b) As to Lessee: Meterology Research, Inc.  
464 West Woodbury Road  
Altadena, California 91001  
Attn: Bob Wiggins, V.P.

18. NO WARRANTIES; ENTIRE AGREEMENT: Lessee agrees that Lessor has made no representation or warranty of any kind, nature or description, express or implied, with respect to Equipment. This Lease and the Schedule or Schedules attached hereto contain the entire agreement between the parties, and Lessor is not bound by any representation or inducements not specifically set forth herein and in the Schedule or Schedules, and may not be changed, modified, terminated or discharged except in writing.

19. ASSIGNMENT: This Lease Agreement may not be assigned by either party without the written consent of the other party except to a successor corporation by merger or consolidation of either party, or to any corporation acquiring substantially all of the property, assets and business or either party by sale, lease or other disposition, or to any corporation controlling, controlled by, or under common control with either party.

20. GOVERNING LAW: This agreement and the performance hereunder shall be governed by the laws of the State of California.

21. HOLDING OVER: In the event of any holding over after the expiration of this Lease Agreement, the same shall be construed to be a month-to-month or period-to-period basis at the same rental as herein described and subject to all the terms of this Agreement, including the right of Lessor to terminate the Lease at any time during such period of holding over.

22. REDELIVERY: Upon surrender or termination of this Lease Agreement as herein provided, Lessee shall return the Equipment to the Lessor in good repair, condition, and working order, ordinary wear and tear resulting from proper use thereof alone excepted.

23. TITLES: The titles to the paragraphs of this Lease are solely for the convenience of the parties and shall in no way be held to explain, modify, amplify or aid in the interpretation of the provisions hereof.

24. LEASE AGREEMENT SCHEDULES: The following Schedules are incorporated into and made a part of this Lease Agreement:

Schedule

Title

I

Equipment Schedule and  
Delivery Schedule

II

Lease prices as shown on  
Proposal to DNA for INS Lease

IN WITNESS WHEREOF, Lessor and Lessee have caused this Lease to be executed by their duly authorized representatives as of the day and year first above written.

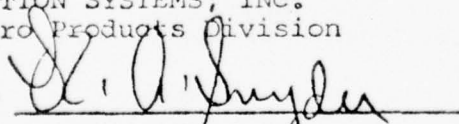
Lessor:

Lessee:

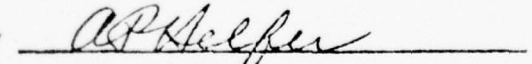
LITTON SYSTEMS, INC.  
Aero Products Division

Meteorology Research, Inc.

By



By



Title

R. A. Snyder  
Manager of Contracts

Title

A. P. Helfer  
President

Date

19 October 1973

Date

25 October 1973

SUPPLEMENT 1-2

Research Aircraft Support for  
HEART, SAMS, and FLAME at Wallops Island

16 November 1974 - 31 January 1975

by

Stefan Steinberg

First issued as Bimonthly Report No. 2, 15 February 1975

1-2.1

## TABLE OF CONTENTS

|       |   | Page  |
|-------|---|-------|
| 1.    | INTRODUCTION  | 1-2.3 |
| 2.    | PROGRESS IN PRINCIPAL TASK AREAS                      | 1-2.3 |
| 2.1   | <u>Lease Citation N511CC</u>                          | 1-2.3 |
| 2.1.1 | <u>Lease Agreement</u>                                | 1-2.3 |
| 2.1.2 | <u>Maintenance and Repair of Aircraft Systems</u>     | 1-2.3 |
| 2.1.3 | <u>Copilot/Crew Chief Support</u>                     | 1-2.4 |
| 2.1.4 | <u>Insurance Coverage</u>                             | 1-2.4 |
| 2.1.5 | <u>Aircraft Flying Time</u>                           | 1-2.4 |
| 2.2   | <u>Coordination of Field Operations</u>               | 1-2.4 |
| 2.3   | <u>Administer Citation Lease</u>                      | 1-2.4 |
| 2.4   | <u>Lease Litton LTN-51 Inertial Navigation System</u> | 1-2.5 |
| 2.4.1 | <u>Lease Agreement</u>                                | 1-2.5 |
| 2.4.2 | <u>Pallet Assembly</u>                                | 1-2.5 |
| 2.4.3 | <u>Emergency Battery</u>                              | 1-2.5 |
| 2.4.4 | <u>Insurance</u>                                      | 1-2.5 |
| 2.4.5 | <u>Installation and Removal</u>                       | 1-2.5 |
| 2.5   | <u>Administer INS Lease</u>                           | 1-2.6 |
| 2.6   | <u>Flight Crew Transportation and Accommodations</u>  | 1-2.6 |
| 3.    | SUMMARY OF CITATION FLIGHTS                           | 1-2.6 |
| 4.    | ACTIVITIES DURING THE NEXT REPORTING PERIOD           | 1-2.6 |

## 1. INTRODUCTION

This document reports on the progress made under Contract DNA 001-75-C-0040. The report covers the period from 16 November 1974 through 31 January 1974.

MRI is supporting DNA and AFCRL in HEART, SAMS, and FLAME hydrometeor sampling programs at Wallops Island, Virginia. Part of this support is an MRI instrumented and operated Cessna Citation sampling aircraft leased for the five month test period 16 November 1974 through 15 April 1975. The instrumentation includes an INS leased from Litton Aero Products and modified specifically for HEART sampling missions.

This report discusses the progress of the Citation lease, the INS lease, Citation flight time and flight crew transportation, accommodations and coordination activities.

## 2. PROGRESS IN PRINCIPAL TASK AREAS

### 2.1 Lease Citation N511CC

#### 2.1.1 Lease Agreement

A lease was negotiated with Alpine Aircraft Charters, Inc., Denver, Colorado, guaranteeing exclusive use of Cessna Citation N511CC beginning on 16 November 1974 and terminating on 15 April 1975. An option to extend the lease was included to allow for the possible extension of test operations beyond the presently scheduled termination date of 31 March 1975.

#### 2.1.2 Maintenance and Repair of Aircraft Systems

Alpine Aircraft Charters, Inc., is maintaining the aircraft, avionics, engines, and subsystems and performing all routine maintenance inspections as per the lease agreement. Maintenance work performed on the aircraft is being scheduled so as not to impact test operations.

#### 2.1.3 Copilot/Crew Chief Support

In accordance with the lease agreement, Alpine Aircraft Charters, Inc., is providing a full-time copilot/crew chief to support all operations during the lease period.

#### 2.1.4 Insurance Coverage

Insurance coverage is being provided by Alpine Aircraft Charters, Inc., and the cost included in the lease price of the aircraft. The insurance coverage is in the following amounts:

- a. Aircraft Hull Insurance - full coverage
- b. Bodily Injury, other than passenger liability - \$250,000
- c. Property Damage - \$500,000 per accident
- d. Passenger Liability - \$100,000 per passenger

The certificate of insurance was included in the previous report.

#### 2.1.5 Aircraft Flying Time

The lease provides for unlimited usage of the aircraft during the period of the agreement.

#### 2.2 Coordination of Field Operations

The MRI program manager is maintaining close contact with DNA and other government agencies to assure full co-ordination of all aircraft operations.

#### 2.3 Administer Citation Lease

The MRI program manager is maintaining close contact with Alpine Aircraft Charters, Inc., to assure all lease provisions are being accomplished and all necessary maintenance is performed on the aircraft. Invoices are examined and flight time charges are verified with any conflicting items being resolved.

## 2.4 Lease Litton LTN-51 Inertial Navigation System

### 2.4.1 Lease Agreement

The lease agreement negotiated with Litton Aero Products provides full-time use of a Litton LTN-51 inertial navigation system for the entire length of the contract period. A semi-annual (6 month), lease was negotiated due to the cost savings compared to a five month period on a monthly cost basis. A copy of the lease was included in the previous report.

### 2.4.2 Pallet Assembly

A special pallet assembly equipped with dual inverters and designed to adopt the Litton LTN-51 installation to aircraft such as the Citation, is included in the lease and has been installed in the Citation.

### 2.4.3 Emergency Battery

In accordance with the lease agreement Litton Aero Products has supplied an emergency battery designed to fit the pallet assembly which assures continued INS operation in the event of any temporary electrical power interruption.

### 2.4.4 Insurance

The lease provides for insurance against all risks or loss or damage from every cause for full replacement value as well as public liability including personal injury and property damage.

### 2.4.5 Installation and Removal

In accordance with the lease, Litton Aero Products is providing field service support for the complete installation, checkout and removal of the INS from the Cessna Citation Aircraft.

2.5 Administer INS Lease

An MRI program manager is administering the provisions of the lease agreement, reviewing all invoices and resolving any conflicting items.

2.6 Flight Crew Transportation and Accommodations

Accommodations have been secured in the vicinity of Wallops Island for the Citation captain, copilot/crew chief, and instrument operator.

3. SUMMARY OF CITATION FLIGHTS

|                   |            |  |
|-------------------|------------|--|
| 19 November       | 0.8        | INS Test Flight                              |
| 17 December       | 5.2        | Ferry Aircraft to Wallops Island from Denver |
| 8 January         | 2.0        | SAMS Mission                                 |
| 20 January        | 5.5        | HEART Mission                                |
| 28 January        | 0.2        | Instrument Test Flight                       |
| 30 January        | 2.1        | Practice FLAME Mission                       |
| 31 January        | <u>2.0</u> | FLAME Mission                                |
| Total Flight Time | 17.8       |  |

4. ACTIVITIES DURING THE NEXT REPORTING PERIOD

During the period from 1 February 1975 through 31 March 1975, the Citation aircraft and its crew will be available for research flights at Wallops Flight Center, Virginia.

SUPPLEMENT 1-3

Research Aircraft Support for  
HEART, SAMS, and FLAME at Wallops Island

1 February 1975 - 31 March 1975

by

Charles Cullian  
Stefan Steinberg

First issued as MRI 75R-1327, 15 April 1975

1-3.1

# TABLE OF CONTENTS

|   | Page   |
|---|--------|
| 1. INTRODUCTION   | 1-3.5  |
| 2. CONTRACT CHANGE OF SCOPE   | 1-3.5  |
| 3. PROGRESS IN PRINCIPAL TASK AREAS   | 1-3.6  |
| 3.1 <u>Lease Citation N511CC</u>  | 1-3.6  |
| 3.1.1 Lease Agreement   | 1-3.6  |
| 3.1.2 Maintenance and Repair of Aircraft Systems  | 1-3.6  |
| 3.1.3 Copilot/Crew Chief Support  | 1-3.6  |
| 3.1.4 Insurance Coverage  | 1-3.6  |
| 3.1.5 Aircraft Flying Time  | 1-3.7  |
| 3.2 <u>Coordination of Field Operations</u>   | 1-3.7  |
| 3.3 <u>Administer Citation Lease</u>  | 1-3.7  |
| 3.4 <u>Lease Litton LTN-51 Inertial Navigation System<br/>for Cessna Citation and P-3A Aircraft</u> | 1-3.7  |
| 3.4.1 Lease Agreements  | 1-3.7  |
| 3.4.2 Pallet Assembly   | 1-3.8  |
| 3.4.3 Emergency Battery   | 1-3.8  |
| 3.4.4 Insurance   | 1-3.8  |
| 3.4.5 Installation and Removal  | 1-3.8  |
| 3.5 <u>Administer INS Lease</u>   | 1-3.8  |
| 3.6 <u>Citation Crew Support for HEART and FLAME<br/>Programs</u>                                   | 1-3.8  |
| 3.6.1 Complete Consulting Agreement   | 1-3.8  |
| 3.6.2 Relocate Crew   | 1-3.9  |
| 3.6.3 Availability of MRI Program Manager and<br>Sensor Technician                                  | 1-3.9  |
| 3.6.4 Logistic Support  | 1-3.9  |
| 3.6.5 Supply Foil Replicator and Portable Instrument<br>Package                                     | 1-3.10 |
| 3.6.6 Citation Flight Hour Summary and Flight Approvals   | 1-3.10 |

# TABLE OF CONTENTS (Continued)

|   | Page   |
|---|--------|
| 4. DATA ANALYSIS FOR HEART, FLAME AND SAMS                            | 1-3.10 |
| 5. SAMPLING MISSION NAVIGATION SYSTEM FOR<br>HEART AND FLAME PROGRAMS | 1-3.12 |
| 5.1 <u>Navigation System Software</u>                                 | 1-3.12 |
| 5.2 <u>Pilot Steering Display</u>                                     | 1-3.12 |
| 5.3 <u>LTN 51 Data Bus Interface</u>                                  | 1-3.13 |
| 6. HOLOGRAPHIC CAMERA SYSTEM  | 1-3.13 |
| 7. ACTIVITIES DURING THE NEXT REPORTING<br>PERIOD                     | 1-3.14 |
| APPENDIX A  | A1-3.1 |
| APPENDIX B  | B1-3.1 |
| APPENDIX C  | C1-3.1 |
| APPENDIX D  | D1-3.1 |
| APPENDIX E  | E1-3.1 |

## 1. INTRODUCTION

This document reports on the progress made under Contract DNA 001-75-C-0040 and modification P00001 for the period from 1 February 1975 through 31 March 1975.

MRI is supporting DNA and AFCRL in HEART, SAMS, and FLAME hydrometeor sampling programs at Wallops Island, Virginia. Part of this support is an MRI instrumented and operated Cessna Citation sampling aircraft leased for the six-month test period 16 November 1974 through 15 May 1975. The instrumentation includes an INS leased from Litton Aero Products and modified specifically for HEART sampling missions. MRI is also responsible for leasing and modifying the INS used in the P-3A support aircraft based at Jacksonville, Florida.

This report discusses the progress of the Citation lease, the INS lease and modification, Citation flight times, flight crew recruiting, transportation, accommodations, and coordination activities.

## 2. CONTRACT CHANGE OF SCOPE

On March 10, 1975, a letter establishing the additional tasks to be performed by MRI was sent to the Defense Nuclear Agency. These tasks included:

- (1) Design, fabricate, and test an electronic interface between the INS and Buffer Memory recording system
- (2) Obtaining FAA approval for the SAI holographic camera installation on the Citation Cloud Physics Research Aircraft and testing the installation in flight.

### 3. PROGRESS IN PRINCIPAL TASK AREAS

#### 3.1 Lease Citation N511CC

##### 3.1.1 Lease Agreement

A lease was negotiated with Alpine Aircraft Charters, Inc., Denver, Colorado, guaranteeing exclusive use of Cessna Citation N511CC beginning on 16 November 1974 and terminating on 15 April 1975. The option to extend the lease which was included to allow for the possible extension of test operations beyond the previously scheduled termination date of 31 March 1975 has been exercised by DNA for one month.

##### 3.1.2 Maintenance and Repair of Aircraft Systems

Alpine Aircraft Charters, Inc., is maintaining the aircraft, avionics, engines, and subsystems and performing all routing maintenance inspections as per the lease agreement. Maintenance work performed on the aircraft is being scheduled so as not to impact test operations.

##### 3.1.3 Copilot/Crew Chief Support

In accordance with the lease agreement, Alpine Aircraft Charters, Inc., is providing a full-time copilot/crew chief to support all operations during the lease period.

##### 3.1.4 Insurance Coverage

Insurance coverage is being provided by Alpine Aircraft Charters, Inc., and the cost is included in the lease price of the aircraft. The insurance coverage is in the following amounts:

- a. Aircraft Hull Insurance - full coverage
- b. Bodily Injury, other than passenger liability - \$250,000

- c. Property Damage - \$500,000 per accident
- d. Passenger Liability - \$100,000

The certificate of insurance was included in the previous report.

#### 3.1.5 Aircraft Flying Time

The lease provides for unlimited usage of the aircraft during the period of the agreement.

#### 3.2 Coordination of Field Operations

The MRI program manager is maintaining close contact with DNA and other government agencies to assure full coordination of all aircraft operations.

#### 3.3 Administer Citation Lease

The MRI program manager is maintaining close contact with Alpine Aircraft Charters, Inc., to assure all lease provisions are being accomplished and all necessary maintenance is performed on the aircraft. Invoices are examined and flight time charges are verified with any conflicting items being resolved.

#### 3.4 Lease Litton LTN-51 Inertial Navigation System for Cessna Citation and P-3A Aircraft

##### 3.4.1 Lease Agreements

The lease agreements negotiated with Litton Aero Products provide for full-time use of two Litton LTN-51 inertial navigation systems for the entire length of the contract period. A semi-annual (six months) lease was negotiated due to the cost savings compared to a five-month period on a monthly cost basis. A copy of the lease was included in the previous report.

#### 3.4.2 Pallet Assembly

Two special pallet assemblies equipped with dual inverters and designed to adopt the Litton LTN-51 installation to aircraft such as the Citation and P-3A, are included in the lease and have been installed in the aircraft.

#### 3.4.3 Emergency Battery

In accordance with the lease agreement, Litton Aero Products has supplied emergency batteries designed to fit the pallet assemblies which assures continued INS operation in the event of any temporary electrical power interruption.

#### 3.4.4 Insurance

The leases provide for insurance against all risks or loss or damage from every cause for full replacement value as well as public liability including personal injury and property damage.

#### 3.4.5 Installation and Removal

In accordance with the lease, Litton Aero Products is providing field service support for the complete installation, checkout, and removal of the INS from the aircraft.

#### 3.5 Administer INS Lease

An MRI program manager is administering the provisions of the lease agreements, reviewing all invoices and resolving any conflicting items.

#### 3.6 Citation Crew Support for HEART and FLAME Programs

##### 3.6.1 Complete Consulting Agreement

A consulting agreement has been negotiated and a Citation rated aircraft captain will be available to support all HEART and

FLAME operations, associated meetings, briefings and alerts, throughout the deployment period at Wallops Flight Center.

#### 3.6.2 Relocate Crew

The MRI Citation support crew, consisting of an aircraft captain, copilot/crew chief, and instrument operator have been relocated to the vicinity of Wallops Flight Center for the duration of the program.

#### 3.6.3 Availability of MRI Program Manager and Sensor Technician

The MRI program manager and sensor service technician are available on an "as needed" basis. The program manager is monitoring the following:

- a. Activities of the crew
- b. Status of the Citation aircraft and its instrumentation package
- c. Procuring and shipping consumable and crew support items as they are needed
- d. Arranging the replacement of crew members as the need arises
- e. Closely monitoring the packaging, shipment, and receipt of data
- f. Handling customer's requests for unspecified services as the need arises.

#### 3.6.4 Logistic Support

All consumable supplies, spare parts, and maintenance kits required to operate the Citation aircraft and its sensor package have been procured and shipped to Wallops Flight Center to be used as needed throughout the program. An MRI program manager is in

daily contact with the support crew and any needed supplies or spare parts are shipped as soon as possible. In this way the aircraft and any part of the sensing package is available for program support in a 100 percent ready condition almost constantly.

3.6.5 Supply Foil Replicator and Portable Instrument Package

One foil replicator, MRI Model 1220A, and one MRI portable instrument package has been provided for the duration of the program.

3.6.6 Citation Flight Hour Summary and Flight Approvals

Appendix E contains a summary of the Citation flight hours and the individual who authorized each particular flight during this reporting period.

4. DATA ANALYSIS FOR HEART, FLAME AND SAMS

The missile operations supported by the MRI Citation during the period between 1 January and 31 March 1975 are listed in the table below.

| Date<br>(1975) | Operation | No. of<br>Missiles<br>Fired | Quick Look<br>Report<br>Issued | Preliminary<br>Data Summary<br>Issued | Final Mission<br>Data Summary<br>Issued |
|----------------|-----------|-----------------------------|--------------------------------|---------------------------------------|---|
| 1-9            | SAMS      | 2                           | 1-9                            | N/A                                   | 4-4                                     |
| 1-20           | HEART     | 1                           | 1-24                           | 2-14                                  | Note 1                                  |
| 2-4            | FLAME     | 1                           | 2-4                            | N/A                                   | N/A                                     |
| 3-5            | HEART     | 0                           | N/A                            | N/A                                   | Note 2                                  |
| 3-7            | SAMS      | 1                           | 3-8                            | N/A                                   | Note 3                                  |

Note 1 and 3: Final mission summaries to be issued by 4-30-75.

Note 2: The only data required from the aborted HEART mission of 3-5-75 are Formvar replicator photographs. For comparison with holographs taken during the return flight to Wallops.

The FLAME mission data were not reduced because the mission was a failure due to missile problems. While similar problems existed on 9 January and 7 March, AFCRL requested that data be processed to allow the degree of correlation between aircraft data and radar data to be studied.

Data processing for all missile operations will be accomplished in cooperation with AFCRL. Dr. Barnes' letter dated 31 January 1975 details handling of SAMS data; this letter is included in Appendix B. HEART and FLAME data will be reduced in a similar fashion with the concurrence of AFCRL as to crystal habit and associated size-mass relationships.

Attempts have been made to derive better crystal habit information through the use of the Quantimet analyzer. Unfortunately, due to contrast problems and data artifacts, objective measurement of crystal types is not possible. The trained eye of the scientist is still required and, due to the volume of data to be studied, the crystal habit determination is still largely qualitative. As a consequence, no charges for use of the Quantimet analyzer will be billed during this program.

The major difference between the SAMS data processing and that of HEART and FLAME is that the SAMS data are compared with radar gathered by Spandar, while the HEART and FLAME data are used solely to characterize the average water content and spectra at each level. Therefore, in addition to the pass average data processed for HEART and FLAME, six-second averages of all probe data are stored on digital tape and delivered to AFCRL for further analysis.

## 5. SAMPLING MISSION NAVIGATION SYSTEM FOR HEART AND FLAME PROGRAMS

MRI has developed novel hardware and software for use with the Litton LTN 51 navigation system to support the HEART and FLAME programs. The system has been completed and used successfully under both test and mission conditions.

### 5.1 Navigation System Software

MRI has directed the efforts of Litton Aero Products in the writing of special software for use with the LTN 51 which would allow the MRI Citation and P-3A aircrafts to "storm follow" while making their post reentry data sampling runs. When the reentry vehicle reaches the pierce point, the mission start switch is activated and the software essentially propagates the coordinate system as the reentry trajectory propagates with the storm. A complete description of the program and its operation is included Appendix C.

### 5.2 Pilot Steering Display

MRI has developed a display system which accepts the LTN 51 track angle error (TKE) three wire synchro signal and conditions it to drive a control transformer display. The electronics and control transformer comprises an off-the-shelf unit which has been mechanically modified to allow an unambiguous steering command to be displayed in the cockpit.

With the use of the special software described in Section 4.1, the track error display need only be kept at zero by aircraft steering to bring the aircraft to the desired sampling points.

The steering display systems are installed in the MRI Citation and the P-3A aircrafts.

### 5.3 LTN 51 Data Bus Interface

Design and fabrication of an electronic interface which interrogates the LTN 51 serial data bus and converts it to a parallel BCD format computable with the Buffer Memory System has been completed. The unit has been installed and tested in the P-3A aircraft and latitude and longitude outputs have been observed on the Buffer Memory nixie tube display.

### 6. HOLOGRAPHIC CAMERA SYSTEM

FAA approval for installation of the SAI holographic camera was finalized in Newark, New Jersey, after a coordinated effort with Butler Aviation and the local General Aviation District Office (GADO).

The Citation was flown to Newark prior to approval in order to familiarize the FAA representative with the proposed installation. Subsequently, all necessary documentation was assembled and submitted to FAA.

Upon receipt of FAA approval, the camera was installed at Wallops Flight Center, Virginia. Documentation is included in Appendix D.

Since its installation, MRI has supported SAI by providing test and operational support as necessary.

Specific comparisons between the DNA Formvar replicator and the SAI holographic system are being made at the request of R. Cunningham, AFCRL, by preparing representative photographs of the crystal habit recorded by the Formvar replicator during the acquisition of each holographic record made on 5 March 1975.

7. ACTIVITIES DURING THE NEXT REPORTING PERIOD

During the period from 1 April through 30 April 1975, the Citation and its crew will be available at Wallops Flight Center to support research activities. This extension of research activity by DNA from the previously scheduled end date of 31 March 1975 will change the decommissioning dates for the Citation research aircraft to 1 May through 15 May 1975, after which time it will be returned to Alpine Aircraft Charters, Inc., in Denver, Colorado.

The navigation systems will be removed from both the P-3A and Citation and returned to Litton Aero Products.

Data processing and mission reporting will continue through the end of the contract period.

APPENDIX A

A1-3.1



meteorology research, inc. • 464 w. woodbury rd. • altadena, calif.

Mailing address:  
Box 657, Altadena,  
Calif. 91001  
Phone: 213 291-1111

March 10, 1975

Headquarters  
Defense Nuclear Agency  
Washington, D. C. 20305

Attn: Jeanne Ryder

Dear Miss Ryder:

Ref: DNA Contract 001-75-C-0040, P00001/MRI 9104141206, 9104141408, 9104141493

Discussions and agreements between DNA/SAMSO and Meteorology Research technical personnel have resulted in changes in the work being performed by Meteorology Research on the subject contract modification (P00001).

As a result of these agreements, it is requested that a contract modification covering the following items be issued at no additional cost to the Government:

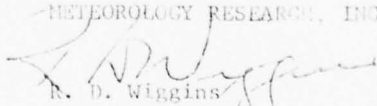
References are to P00001 of the basic contract.

ARTICLE I, SCOPE OF WORK

Under paragraph "D.", page 3. delete items 5,6,7,8, and 9, and substitute the following:

5. Design and fabricate an electronic interface to interrogate the LTN 51 to obtain position data from the serial data bus and convert it to a parallel BCD format compatible with the Buffer Memory and recording systems.
6. Install and test the operation of the MRI position data interface on the P-3A Weather Reconnaissance aircraft.
7. Acquire FAA approval for the installation of the SAI holographic camera system on the Citation Cloud Physics Research Aircraft.
8. Install and operate the SAI holographic camera system on the Citation Cloud Physics Aircraft.

If you have questions, please contact me.

Sincerely,  
METEOROLOGY RESEARCH, INC.  
  
R. D. Wiggins  
Vice Pres. Adm. & Finance

RDW:mhh

cc: Col. R. Huston

A Subsidiary of Puka Inc.

APPENDIX B

B1-3.1

LYC (Dr. Barnes, X-3284)

31 January 1975

Citation/SAMS Data Required by AFCRL

HQ SAMSO/RSSE (Capt Pisarczyk)

1. The following information is provided for the work statement for the MRI contract, concerning the data to be provided to AFCRL from the Citation for SAMS V missions.

a. AFCRL needs the following:

(1) In real time while the Citation is making measurement passes, shortly before or after the mission.

(a) At least two time checks (GMT time) during flight along with deviation from WOCC time if any.

(b) Time, with remarks on the weather, on passing points L and K, the beginning and end points of the passes.

(c) Altitude of the pass. Pressure altitude with altimeter set to 29.92.

(d) General comments on the visually observed weather.

(e) When feasible for each pass, a sample count of PMS channels. This would be specified by the AFCRL Field Director from the WOCC and would usually be a visual estimate of the average one second counts in channels 1 and 4 or 2 and 5 of the precipitation probe. This information will be provided on request only.

(2) In order to aid in the preparation of the 48 hour TWX, the AFCRL Field Director needs by 36 hours after the shot the following:

(a) Times (GMT) of the beginning and ending of each run, the pressure altitude of the run and an indicated temperature and airspeed.

(b) Pertinent comments on the observed weather during the flight.

(c) If the local Salisbury computer can be used, a print-out of the average particle concentration per channel for each PMS probe (average or total) for each pass is desired. Particle count per channel for each pass could be supplied in lieu of the above.

(d) The degree of success of the operation of each major piece of equipment during the flight, i.e., the PMS probes, the foil, replicator and temperature probe. If there was a problem, a short statement of the nature of the problem is desired.

(3) In the longer time scale, it is requested that the crystal habit or percent of each crystal habit identified per pass be discussed with AFCRL before the further processing of the PMS data tapes. For this purpose the foil and replicator data should be examined but no extensive analysis of these data are presently programmed.

(a) The catalog of shadow length to mass relationships that are used in the analysis of the PMS data should be supplied to AFCRL.

(b) After crystal type of mix per pass has been agreed to by AFCRL and MRI the PMS raw tape data should be transferred to a Kwajalein type tape and this tape sent to AFCRL/LYC to arrive NLT 30 days after mission. Crystal habit or percent mix used for each pass should be included.

(c) A summary listing of particle concentration and INC per pass should be provided similar in format to that in MRI report on HEART mission on 25 March 1974, report dated 23 April 1974.

ARNOLD A. BARNES, Jr., Acting Chief,  
Convective Cloud Physics Branch  
Meteorology Laboratory

Cy to: DMA (Capt R. Houston)  
MRI (Mr. R. Davey)  
SAMSO (Mr. J. Hess)  
LY (Dr. R. Cunningham)  
LYC (Mr. M. Glass)

APPENDIX C

C1-3.1




CONTRACT NO.  
RELEASE DATE

NOV 15 '74

REVISIONS

| LTR | ECO | DESCRIPTION | DATE | APPROVED |
|-----|-----|-------------|------|----------|
|     |     |             |      |          |

|                         |  |  |                |               |     |
|-------------------------|--|--|----------------|---------------|-----|
| CONTRACT NO.            |  |  <b>AERO PRODUCTS DIVISION</b><br>LITTON SYSTEMS, INC. LITTON INDUSTRIES<br>CANOGA PARK, CALIFORNIA 91303 |                |               |     |
| SIGNATURES              |  | TITLE  |                |               |     |
| DR- <i>[Signature]</i>  |  | COMPUTER PROGRAM 100551  |                |               |     |
| CHK                     |  | Meteorology Research Inc.  |                |               |     |
| ENGR <i>[Signature]</i> |  |  |                |               |     |
| ENGR                    |  |  |                |               |     |
| APD APPROVAL            |  | SIZE   | CODE IDENT NO. | NUMBER        | REV |
|                         |  | A  | 30782          | 454-47-100551 |     |
| CUSTOMER APPROVAL       |  | SCALE  | SHEET 1 OF 12  |               |     |

M APD 51-10

C1-3.3

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### GENERAL

The LTN-51 operational computer program 100551 was written to meet the requirement of the Meteorology Research Inc. of California. The program provides steering commands to trace a series of moving points in space in addition to normal LTN-51 functions.

### PROGRAM CHARACTERISTICS IN NORMAL LTN-51 OPERATIONS

Turn-On - When the mode selector switch is set to STBY, turning on the system; the right numerical CDU display will indicate the computer program number 100551 (Display Selector must be in POS or WPT). The left numerical display will be all zeros and the FROM/TO display will indicate a CI track. After a position data entry has been made, the right numerical display will not display the computer program number.

Waypoint Zeroing - Present Position and Waypoints 0 through 9 will be zeroed whenever the mode selector switch is set from OFF to STBY or from NAV to STBY. The computer program number will be displayed in the right numerical display with Display Selector switch set to POS or WPT.

Display Test - During STBY and ALIGN modes, with the CDU Display Selector switch set to TEST; left and right numerical displays are degree signs, decimal point, arc-minute sign, NS, EW, and all "8's". From/To display is "88" and ALERT, BATT and WARN annunciators are on. The computer will output analog test values:

| <u>Parameter</u>         | <u>Value</u>   |
|--------------------------|--|
| Analog True Heading      | 11.25 degrees  |
| Analog Track             | 22.5 degrees   |
| Analog Drift Angle       | 11.25 degrees  |
| Analog Track Angle Error | 22.5 - (Desired Track)   |
| Analog TAE + DA          | (Desired Track) - (Acft. True Heading)                             |
| Ground Speed             | 512 knots groundspeed is simulated for steering signal computation |

The ARINC Transmitter will output "8's" and the INS Comparison Warn signal will be set to the warn condition.

|                  |                                |                         |     |
|------------------|--------------------------------|-------------------------|-----|
| SIZE<br><b>A</b> | CODE IDENT NO.<br><b>30782</b> | NUMBER<br>454047-100551 | REV |
| SCALE            |                                | SHEET 2 OF              |     |

FORM AFD 51-102

# Alignment Status Values

| <u>STS</u> | <u>DESCRIPTION</u>  |
|------------|---|
| 90         | First 60 seconds after turn-on during which the Gimbal is caged and the gyros are spun up.  |
| 80         | Analog fast level mode, lasts 120 seconds. Alignment will be held in STS 80 until present position has been entered and the MSU mode switch is set to ALIGN.        |
| 70         | Digital fast level mode, lasts 100 seconds (Align timer = 220 seconds). Alignment held in STS 70 until the platform up-to-temp discrete is received by the computer |
| 60         | Velocity averaging mode, lasts 25 seconds, at end of which alpha estimation is tested for reasonableness.   |
| 50         | Damping mode lasts for 120 seconds during which velocities are allowed to dampen out after direction cosine update.   |
| 40         | Alignment gains are changed for fine gyrocompassing. This period last 120 seconds.  |

At the end of STS 40 fine gyrocompassing continues. The status number displayed indicates the largest of the following three quantities; Vx pulses, Vy pulses or north gyro drift. Status value associated with measured north gyro bias have the following correspondence;

| <u>STATUS</u> | <u>NORTH CYRO BIAS</u>       |
|---------------|------------------------------|
| 0             | Less than 0.036 degrees/hour |
| 1             | 0.036 to 0.072 degrees/hour  |
| 2             | 0.072 to 0.112 degrees/hour  |
| 3             | 0.112 to 0.148 degrees/hour  |

A status value of 2 or less must be achieved for the Ready Nav Annunciation on the MSU to illuminate. North gyro bias measured must be less than 0.112 degrees/hour.

|                  |                                |                         |     |
|------------------|--------------------------------|-------------------------|-----|
| SIZE<br><b>A</b> | CODE IDENT NO.<br><b>30782</b> | NUMBER<br>454047-100551 | REV |
| SCALE            |                                | SHEET 3 OF              |     |

FORM APD 51-10-2

#### Alignment Warnings

1. At the end of STS 60, if test of  $0.875 < (\sin^2 \text{Alpha} + \cos^2 \text{Alpha}) < 1.125$  fails for three consecutive 25 second velocity averaging periods (STS 60); the flashing warn is activated. STS 60 is maintained during this period.
2. Below STS 80 (i.e.;  $70 \rightarrow 0$ ) the flashing warn is activated anytime  $V_x$  or  $V_y$  exceeds (overflow) a predetermined value for more than three real time interrupt cycles. Alignment is reset at STS 70.
3. A flashing warn will be activated if Ready Nav criteria is not satisfied within two minutes after completing the fine gyrocompassing time of eight minutes.
4. If the Align mode is maintained after a Ready Nav light is obtained; a flashing warn will be activated if the status value exceeds 2 for a period longer than two minutes. The Ready Nav light will be extinguished. Warning light will extinguish and Ready Nav will illuminate any time the status is 2 pulses or less.

#### Analog output Characteristics

1. Analog true heading (TR HDG) is updated ten times a second.
2. Drift angle (DA) and DA + track angle error (TKE) are selected as analog output signals.
3. ARINC steering signals are available on track angle error converter if LTP-13 is grounded to LTP-3.
4. Steering signal output is limited at  $\pm 30$  degrees bank angle command.

#### Track Switching Characteristics

1. Auto mode - If Steering Discrete (LTP-13) is grounded to LTP-3; track leg switching is executed at 30 seconds time to go. ALERT light will illuminate at two minutes time to go if ground speed is greater than 250 knots.
2. Manual Mode - Switching point mechanization is the same as above with the exception that track change is not made automatically. In lieu of the automatic track change; the ALERT light is flashed as an indication to the operator to change track manually. ALERT light flashing begins 0.5 minutes time to go.

|       |                |               |      |
|-------|----------------|---------------|------|
| SIZE  | CODE IDENT NO. | NUMBER        | REV  |
| A     | 30782          | 454047-100551 |      |
| SCALE |                | SHEET         | 4 OF |

FORM AFD 51-10-2

#### Track Hold Mode

1. A Desired Track may be inserted into the computer to provide an INS Track Hold mode. With the CDU Display Selector switch set to DSR TK/STS position, the desired angle is entered by depressing the 0 button on the CDU and inserting the angle to the nearest 0.1 degrees in the left numerical display.
2. DIS, TIME and XTK values will be zero and the FROM/TO display will indicate 99.

#### Distance Between Waypoints in Normal LTN-51 Operations

1. Set the CDU AUTO/MAN/RMT switch to RMT. The FROM/TO display will blink.
2. Set display selector to DIS/TIME. Left numerical display will be 0000.
3. Enter track change between waypoints to be interrogated. The left numerical display will be the distance between these waypoints. Normal track distance calculations and track switching continues, uninterrupted during waypoint interrogation.
4. Switching to AUTO or MAN restores the normal FROM/TO and DIS display.

#### BCD bus characteristics

| Label (Octal) | Quantity          | Units     | Resolution |
|---------------|-------------------|-----------|------------|
| 1             | Distance to Go    | Nm        | 0.1 Nm     |
| 2             | Time to Go        | Min       | 0.1 Min    |
| 5             | Track angle error | Deg       | 0.1 Deg    |
| 10            | Latitude          | Deg & Min | 0.1 Min    |
| 11            | Longitude         | Deg & Min | 0.1 Min    |

#### Display Restrictions in Normal LTN-51 Operations

1. For ground speed equal to or less than 10 knots, track is set equal to true heading and time to go is set to zero.
2. For a FROM/TO track of 00 (also present position has not been entered), DSR TK, TKE, XTK, DTG and TTG are set to zero.

#### Wind Computations

Computer program is capable of computing wind speed and direction based on keyboard entry of true air speed.

|                  |                                |                         |     |
|------------------|--------------------------------|-------------------------|-----|
| SIZE<br><b>A</b> | CODE IDENT NO.<br><b>30782</b> | NUMBER<br>151057-100551 | REV |
| SCALE            |                                | SHEET                   | OF  |

FORM APD 51-102

#### MAINTENANCE INFORMATION

##### Tape Verification

Verification of computer program fill starts at location 0000.

##### Gyro Bias and scale factor locations -

| <u>Location</u> | <u>Parameters</u>                     |
|-----------------|---------------------------------------|
| 7004            | BXDT, X gyro bias                     |
| 7005            | BYDT, Y gyro bias                     |
| 7006            | BZDT, Z gyro bias                     |
| 7007            | GSX, Modifier for X gyro scale factor |
| 7010            | GSY, Modifier for Y gyro scale factor |

#### PROGRAM CHARACTERISTICS IN MRI MISSION OPERATIONS

##### Sampling mission switching characteristics -

1. A discrete toggle switch labelled 'MISSION START' will be employed and must be heavily detented in the ON position to prevent inadequate turn off during mission operations.
2. Switch in the OFF position - The normal align and navigate functions of a standard LTN-51 system shall be performed.
3. Switch in the ON position - The switch will be placed in the ON position in the NAV mode and enables entry of all mission data parameters. The placing of the switch to the ON position starts the real time integration to update the relative position of aircraft with respect to moving sampling point.

##### Mission data entry and display

The 'MISSION START' switch will be set to ON position a first time to load the following data:

1. Storm direction and velocity
  - a. Set AUTO/MAN/RMT switch to AUTO or MAN.
  - b. Set selector switch to DSR TK/STS
  - c. Set WPT # to 0
  - d. Press the '0' key for left display and enter storm direction to the nearest tenth of a degree.
  - e. Press the '5' key for right display and enter storm speed to a knot.

|       |                |               |     |
|-------|----------------|---------------|-----|
| SIZE  | CODE IDENT NO. | NUMBER        | REV |
| A     | 30782          | 454047-100551 |     |
| SCALE |                | SHEET         | OF  |

FORM AFD 51102

2. Azimuth angle and glide ratio

- a. Leave AUTO/MAN/RMT switch to AUTO or MAN.
- b. Set selector switch to DSR TK/STS
- c. Set WPT # to 1.
- d. Press the '0' key for left display and enter azimuth angle to the nearest tenth of a degree.
- e. Press the '5' key for right display and enter glide ratio to a feet (feet in horizontal plane per 1000 ft change in altitude).

Note: Typically the switch will be placed to the OFF position after the above parameters are loaded and normal LTN-51 operations will be performed.

The 'MISSION START' switch will be placed in the ON position a second time at the instant the re-entry vehicle arrives at the pierce point and the following data shall be loaded.

3. Pierce Point latitude and longitude

- a. Set AUTO/MAN/RMT switch to AUTO or MAN
- b. Set display selector switch to WPT
- c. Set WPT # to 9
- d. Press the 'N' or 'S' key and enter the latitude to the nearest tenth of a degree
- e. Press the 'E' or 'W' key and enter the longitude to the nearest tenth of a degree.

4. Pierce Point altitude

- a. Set AUTO/MAN/RMT switch to AUTO or MAN
- b. Set display selector switch to DSR TK/STS
- c. Set WPT # to 9
- d. Press the '5' key for right display and enter the first two digits of altitude in unit 1000 ft.

Example - For 35,200 ft. enter 35  
for 5,200 ft. enter 5

|       |                |               |     |
|-------|----------------|---------------|-----|
| SIZE  | CODE IDENT NO. | NUMBER        | REV |
| A     | 30782          | 454047-100551 |     |
| SCALE |                | SHEET 7       | OF  |

FORM APD 55-102

5. Desired altitude of the first point to be sampled.
  - a. Set AUTO/MAN/RMT switch to MAN
  - b. Press the TK CHG pushbutton
  - c. Enter the first two digits of desired altitude in unit 1000 ft through the CDU keyboard.
  - d. Press the INSERT pushbutton. The FROM/TO waypoints display should read the numbers inserted and the lights on TK CHG and INSERT will go out.

Note: Automatic track change shall not occur with mission start switch ON position. The selection of the desired tangent plane shall be performed manually by entering the altitude using the procedure cited in 5.

6. Entry of true air speed (TAS)
  - a. Set AUTO/MAN/RMT switch to RMT
  - b. Set display selector switch to DSRTK/STS
  - c. Press the '5' key for right display and enter true air speed to a knot

Note: The entry of true air speed is available for both positions of of 'MISSION START' switch. Set AUTO/MAN/RMT switch to AUTO or MAN to display computed wind speed and direction.

#### Summary of Data Entry and Display

| Parameter      | displayed      | CDU            | A/M/R          | CDU Sel        | WPT            | Mission      |
|----------------|----------------|----------------|----------------|----------------|----------------|--------------|
| <u>Lt Disp</u> | <u>Rt Disp</u> | <u>To/From</u> | <u>Sw. Pos</u> | <u>Sw. Pos</u> | <u>Sw. Pos</u> | <u>Start</u> |
| Storm          | Storm          | --             | A or M         | DSRTK/STS      | 0              | ON           |
| Direction      | Speed          |                |                |                |                |              |
| Azimuth        | Glide          | --             | A or M         | DSRTK/STS      | 1              | ON           |
| Angle          | Ratio          |                |                |                |                |              |
| Pierce Pt      | Pierce Pt      | --             | A or M         | WPT            | 9              | ON           |
| Latitude       | Longitude      |                |                |                |                |              |
| --             | Pierce Pt.     | --             | A or M         | DSRTK/STS      | 9              | ON           |
|                | Altitude       |                |                |                |                |              |
| --             | --             | Desired        | M              | Any            | Any            | ON           |
|                |                | Altitude       |                |                |                |              |
| ---            | TAS            | --             | R              | DSRTK/STS      | Any            | ON/OFF       |

|       |                |               |     |
|-------|----------------|---------------|-----|
| SIZE  | CODE IDENT NO. | NUMBER        | REV |
| A     | 30782          | 454047-100551 |     |
| SCALE |                | SHEET 8 OF    |     |

FORM APD 51-102

Display Restrictions in MRI mission operations -

1. XTK is set to zero with 'MISSION START' switch in ON position.
2. To display desired track (DSR TK) set display selector switch to DSR TK/STS and set wpt # to 2.

Alert light characteristics in MRI mission operations -

1. Alert light and remote alert light will illuminate 1 minute time to go prior to reaching sampling point and remain illuminated for 2 minutes.
2. ALERT will not illuminate unless desired altitude is entered and selection of tangent plane where the sampling will be performed is completed.

GENERATION OF STEERING COMMANDS

Coordinate system used -

A locally level rectangular coordinate system moving in storm direction with storm speed has been used. (Refer to Figure 1)  
In this system X is north, Y is east and Z is up. The center of the coordinate system is referenced to the position of mission aircraft at the instant the 'MISSION START' switch is placed in ON position. The altitude of  $P_o$  is assumed as pierce point altitude.

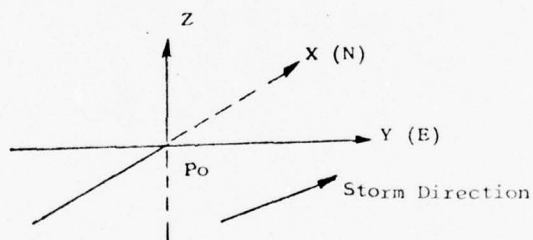


Figure 1

| SIZE  | CODE IDENT NO. | NUMBER        | REV |
|-------|----------------|---------------|-----|
| A     | 30782          | 454047-100531 |     |
| SCALE |                | SHEET         | OF  |
|       |                |               |     |

FORM APD 51-10-2



TTG : Time to go to intercept the sampling point  
 DIST : Distance to go to intercept the sampling point  
 TKP : Relative track angle of A/C in moving coordinate system  
 GSP : Relative ground speed of A/C in moving coordinate system  
 VXS : Storm speed along X-axis  
 VYS : Storm speed along Y-axis  
 VN : A/C speed along X-axis  
 VE : A/C speed along Y-axis  
 Vs : Storm speed  
 TKEP : Track angle error in moving coordinate system  
 VN-VXS : Relative A/C speed along X-axis in moving coordinate system  
 VE-VYS : Relative A/C speed along Y-Axis in moving coordinate system

Then,

$$XRTTP = \phi_{pp} - \phi_o$$

$$YRTTP = (\lambda_{pp} - \lambda_o) \cdot \cos \phi_o$$

$$XDIF = \rho \cos \psi_{az}$$

$$YDIF = \rho \sin \psi_{az}$$

$$VXS = \rho \cos \psi_s$$

$$VYS = V_s \sin \psi_s$$

$$XS = \int (VN - VXS) dt$$

$$YS = \int (VE - VYS) dt$$

$$TKP = \tan^{-1} \left( \frac{VE - VYS}{VN - VXS} \right)$$

$$GSP = \sqrt{(VE - VYS)^2 + (VN - VXS)^2}$$

$$XDIST = XRTTP + XDIF - XS$$

$$= XRTTP + XDIF + \int (VXS - VN) dt$$

|       |                |               |     |
|-------|----------------|---------------|-----|
| SIZE  | CODE IDENT NO. | NUMBER        | REV |
| A     | 30782          | 454047-100551 |     |
| SCALE | SHEET 11 OF    |               |     |

FORM APD 31-10-2

$$YDIST = YRTPP + YDIF - Ys$$

$$= YRTPP + YDIF + \int (VYS - VE) dt$$

$$DIST = \sqrt{(XDIST)^2 + (YDIST)^2}$$

$$\psi_d = \tan^{-1} \left( \frac{YDIST}{XDIST} \right)$$

$$TTG = DIST/GSP$$

$$TKEP = TKP - \psi_d$$

Summary of MRI mission operations -

1. Set 'MISSION START' switch to ON position in NAV mode
2. Enter the available mission data parameters
  - a. Storm speed and direction
  - b. Azimuth angle and glide ratio of re-entry vehicle
  - c. True air speed (available for both positions of 'MISSION START' switch)
3. Set 'MISSION START' switch to OFF position and insert adequate track leg for normal LTN-51 operations.
4. Set 'MISSION START' switch to ON position a second time at the instant the re-entry vehicle arrives at the pierce point.
5. Enter the following data
  - a. Pierce point latitude/longitude
  - b. Pierce point altitude
  - c. First desired sampling altitude
6. When the INSERT pushbutton is pushed to enter the first desired sampling altitude, the displayed values on CDU, DTG, TTG, DSRTK and TKE are the necessary steering commands for the mission operations.
7. Start sampling when the ALERT light illuminates 1 minute time to go prior to reaching the point.
8. During the period of changing altitude, set display selector switch to DIS/TIME and observe relative position of airplane to next sampling point.
9. When the mission airplane enters the tangent plane where the sampling will be performed, insert the first two digits of desired altitude in unit 1000 feet.

|                  |                                |                         |     |
|------------------|--------------------------------|-------------------------|-----|
| SIZE<br><b>A</b> | CODE IDENT NO.<br><b>30782</b> | NUMBER<br>454047-100551 | REV |
| SCALE            |                                | SHEET 12 OF 12          |     |

FORM APD 51-10-2

APPENDIX D

D1-3.1

DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

---

150 Riser Road  
Teterboro Airport  
Teterboro, New Jersey  
07608



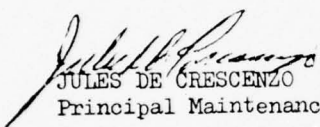
February 19, 1975

Mr. C. Cullian  
c/o Pleasant Acres (Schaff)  
Church Street Extended  
Chincoteague, Virginia 23336

Dear Mr. Cullian:

Attached is the Citation file. Please attach the original letter from Mr. Clarence D. Fields regarding the flight check to the approved Form 337 dated June 24, 1974.

Sincerely,

  
JULES DE CRESCENZO  
Principal Maintenance Inspector

Enclosures

October 31, 1973

GENERAL AVIATION DISTRICT OFFICE  
Ontario International Airport  
Ontario, California 91761

OPERATION LIMITATIONS  
RESTRICTED-MULTIPLE

MAKE: Cessna  
Model: 500

REGISTRATION NO: N511CC  
Serial NO: 500-001

WEATHER CONTROL

The aircraft identified above has been certificated under the provisions of Part 21.187 of the Federal Aviation Regulations for the special purpose(s) as indicated.

1. This aircraft shall not be operated in any manner which will endanger public life or property.
2. All flights shall be conducted in accordance with part 91.39 of the Federal Aviation Regulations, except as noted herein.
3. Conversion from one category to the other shall be performed by or under the supervision of a properly certificated mechanic or in accordance with FAA approved instructions, as appropriate.
4. A log book entry shall be made by a certificated mechanic for each conversion from one category to the other, or recorded in accordance with FAA approved instructions, as appropriate.
5. When operating under these limitations the word "RESTRICTED" in letters at least 2" high shall be made visible from each side of the aircraft near the cabin doors.
6. Flight crews shall be thoroughly briefed on special flight operations and duties.
7. These limitations are issued in conjunction with and in addition to the Special Airworthiness Certificate  
FAA Form 8130.7, dated 10-32-73

*M. Stout*  
M. STOUT  
General Aviation Maintenance Inspector

cc: File  
AAC-250  
Reading  
MS

MS:mhp

| DEPARTMENT OF TRANSPORTATION<br>FEDERAL AVIATION ADMINISTRATION  |   |  |  | Form Approved<br>Budget Bureau No. 04-R060.1                  |            |
|--|---|--|--|---|------------|
| MAJOR REPAIR AND ALTERATION<br>(Airframe, Powerplant, Propeller, or Appliance)   |   |  |  | FOR FAA USE ONLY  |            |
|  |   |  |  | OFFICE IDENTIFICATION   |            |
| INSTRUCTIONS: Print or type all entries. See FAR 43.9, FAR 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form.  |   |  |  |   |            |
| 1. AIRCRAFT  | MAKE<br>Cessna - Citation   |  | MODEL<br>500   |   |            |
|  | SERIAL NO.<br>500-0011  |  | NATIONALITY AND REGISTRATION MARK<br>N511CC  |   |            |
| 2. OWNER   | NAME (As shown on registration certificate)<br>Cessna Financing Corp.<br>Leasing Division |  | ADDRESS (As shown on registration certificate)<br>P. O. Box 303<br>Wichita, Kansas |   |            |
|  | 3. FOR FAA USE ONLY   |  |  |   |            |
| See Reverse Side   |   |  |  |   |            |
| 4. UNIT IDENTIFICATION   |   |  |  |   | 5. TYPE    |
| UNIT   | MAKE  | MODEL  | SERIAL NO.   | REPAIR  | ALTERATION |
| AIRFRAME   | ***** (As described in item 1 above) *****  |  |  |   | X          |
| POWERPLANT   |   |  |  |   |            |
| PROPELLER  |   |  |  |   |            |
| APPLIANCE  | TYPE  |  |  |   |            |
|  | MANUFACTURER  |  |  |   |            |
| 6. CONFORMITY STATEMENT  |   |  |  |   |            |
| A. AGENCY'S NAME AND ADDRESS   |   | B. KIND OF AGENCY  |  | C. CERTIFICATE NO.  |            |
| William R. McFall<br>Alpine Air Charter<br>Stapleton Int'l. Airport<br>Denver, Colorado 80200  |   | <input checked="" type="checkbox"/> U.S. CERTIFICATED MECHANIC |  | A&P<br>2080306  |            |
|  |   | <input type="checkbox"/> FOREIGN CERTIFICATED MECHANIC         |  |   |            |
|  |   | <input type="checkbox"/> CERTIFICATED REPAIR STATION           |  |   |            |
|  |   | <input type="checkbox"/> MANUFACTURER                          |  |   |            |
| D. I certify that the repair and/or alteration made to the unit(s) identified in item 4 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge. |   |  |  |   |            |
| DATE<br>June 24, 1974  |   |  | SIGNATURE OF AUTHORIZED INDIVIDUAL<br><i>William R. McFall</i>                     |   |            |
| 7. APPROVAL FOR RETURN TO SERVICE  |   |  |  |   |            |
| Pursuant to the authority given persons specified below, the unit identified in item 4 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is <input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED  |   |  |  |   |            |
| BY   | FAA FLT. STANDARDS INSPECTOR  | MANUFACTURER   | X  | OTHER (Specify)   |            |
|  | FAA DESIGNEE  | REPAIR STATION   |  |   |            |
| DATE OF APPROVAL OR REJECTION<br>6-24-74   |   | CERTIFICATE OR DESIGNATION NO.<br>1304444                      |  | SIGNATURE OF AUTHORIZED INDIVIDUAL<br><i>Robert E. Bernal</i> |            |

FAA Form 337 (7-67)

GPO : 1971 O - 419,878

(8320)

## NOTICE

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED (If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)

Following alteration performed on Cessna Citation S/N 500-0011 Reg. No. N511CC on June 24, 1974.

Removed center section of modified left rear passenger window (5.5"x14.5"). Installed holo camera mount center section of same dimension by same attaching method. Installed aerodynamic fairings (2) over camera lens as shown in accompanying photograph with 8 high tensile strength bolts.

Accompanying Science Applications, Inc. engineering analysis verifies structural integrity of new center section for 8.0 p.s.i. differential.

This Modification accomplished using Cessna Citation approved manuals and AC 43.13-1 and -2 as guides.

Also installed Holocamera control unit in left rear passenger compartment on seat rails at fuselage station 239.90".

Weight and Balance updated and correct.

Attached are: 2 Photos  
SAI Design Addendum #1  
SAI Design Document #2

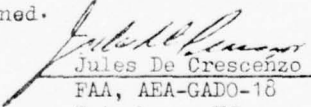
Note: 3-14-75

This aircraft was issued a multiple Airworthiness Certificate on October 31, 1973. The installation described in Item 8 Form 337 dated June 24, 1974 is added equipment to provide data in conjunction with equipment previously installed and approved for weather gathering data.

Conformity inspection was accomplished on June 24, 1974 in accordance with FAR 43.7. Data for this added equipment is approved to conduct flights in the restricted category only.

See attached flight check statement by pilot concerned.

Approving Inspector

  
Jules De Crescenzo  
FAA, AEA-GADO-18  
Teterboro, NJ

☐ ADDITIONAL SHEETS ARE ATTACHED

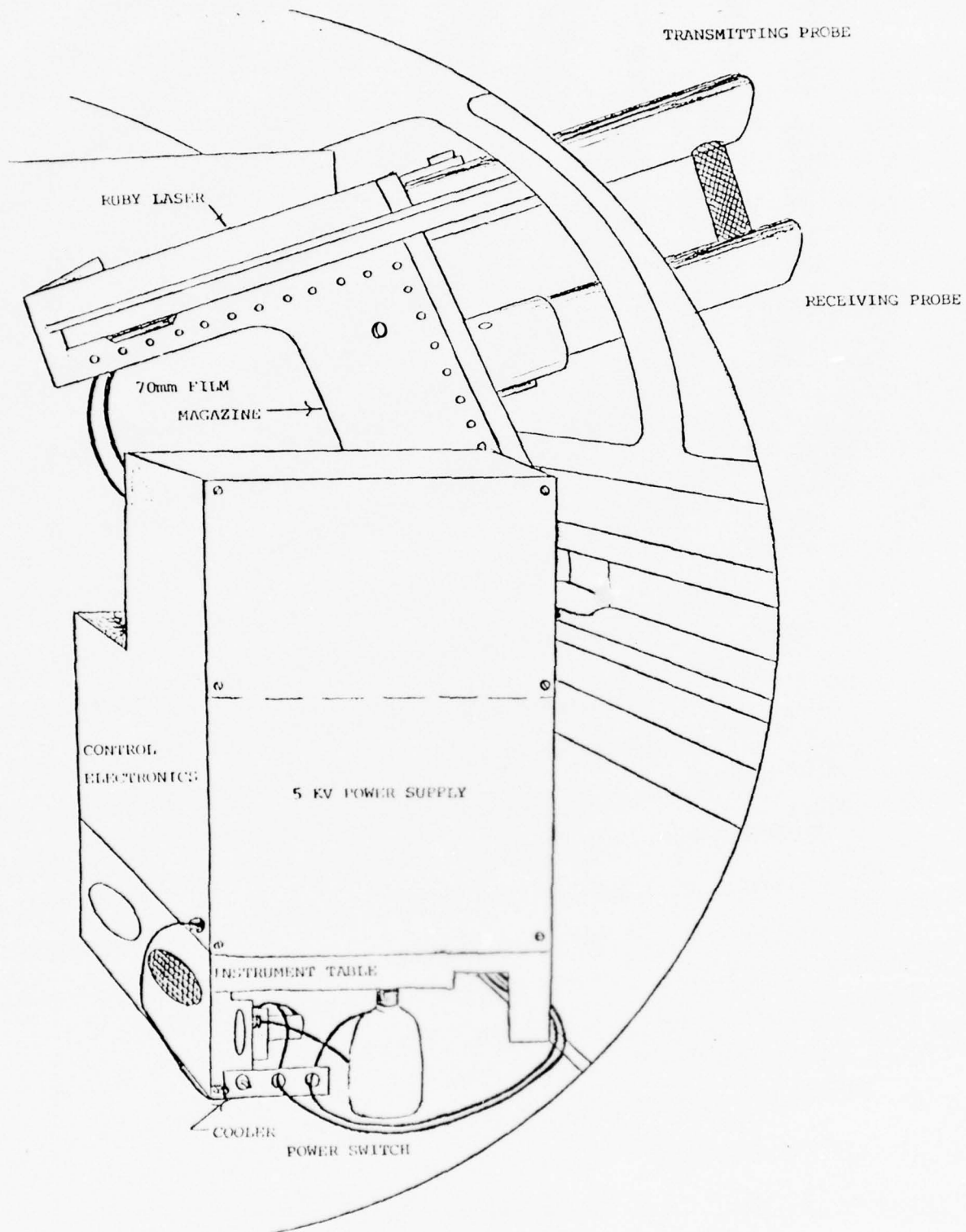
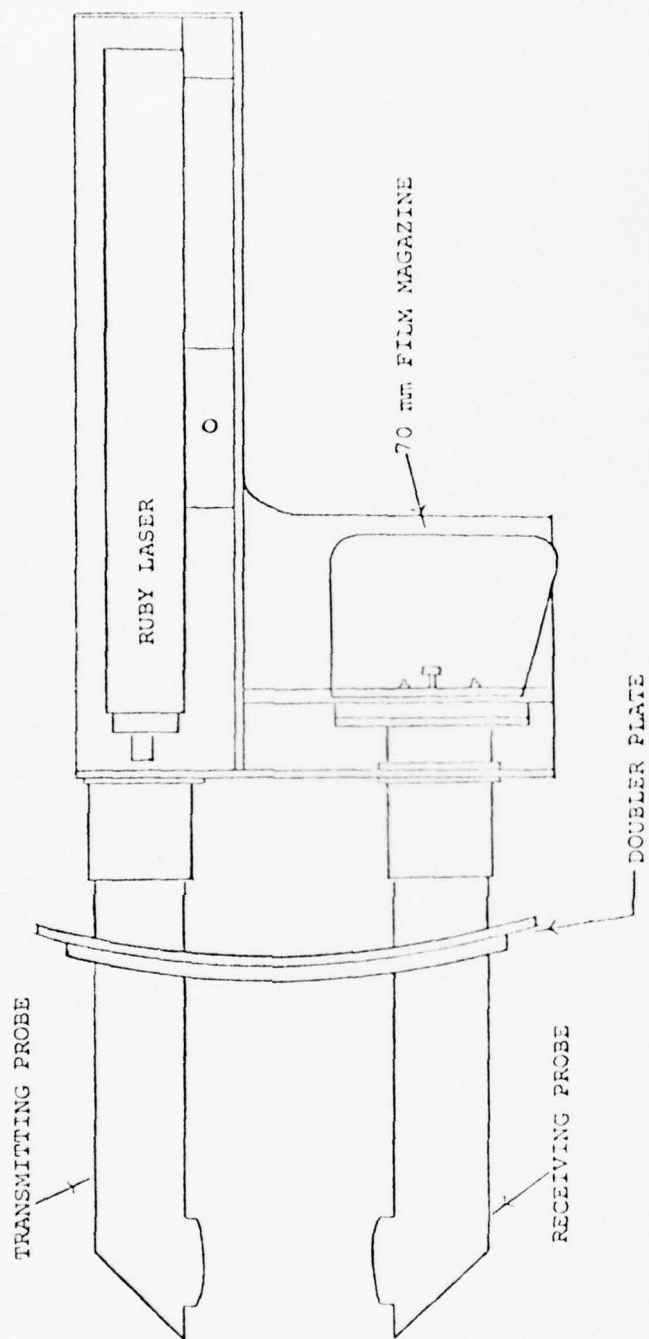


FIGURE 1: HOLOCAMERA INSTALLATION LOOKING AFT

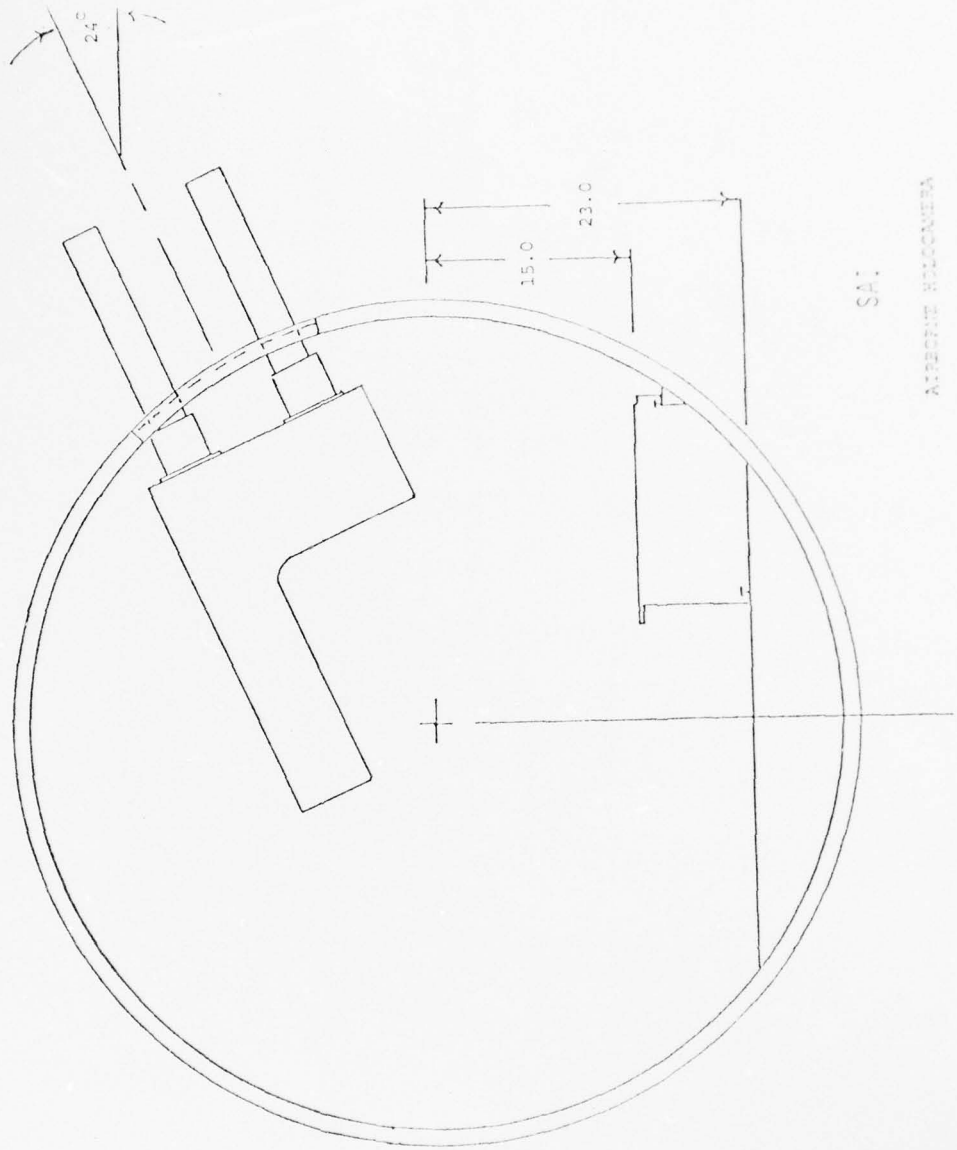


SCALE 1:6

FIGURE 3: HOLOCAMERA ASSEMBLY

SCALE 1:10

CESSNA/CITATION



SA:

APPROVED FOR RELEASE

$$\begin{aligned}\text{Min Cross Section} &= A_s = (\text{Length of Weld}) (.7) (\text{Fillet Size}) \\ &= (\pi) (D) (.7) (R)\end{aligned}$$

Substituting:

$$S_s = \frac{F}{A_s} = \frac{\Delta p \pi D^2}{4 \pi (D) (.7) (R)}$$

$$= \frac{\Delta p D}{2.8R}$$

$$\text{for } \Delta p = 10 \text{ psi}$$

$$D = 2.75 \text{ in.}$$

$$R = .185 \text{ in. (3/16 nominal)}$$

$$S_s = \frac{(10) (2.75)}{(2.8) (.185)}$$

$$= 54 \text{ psi}$$

$$\text{Safety Factor} = \frac{S_s \text{ yield}}{S_s}$$

From Table 44 "Structural Aluminum Design" by Reynolds Metals

$$S_s \text{ yield} = 9,000 \text{ psi for weld}$$

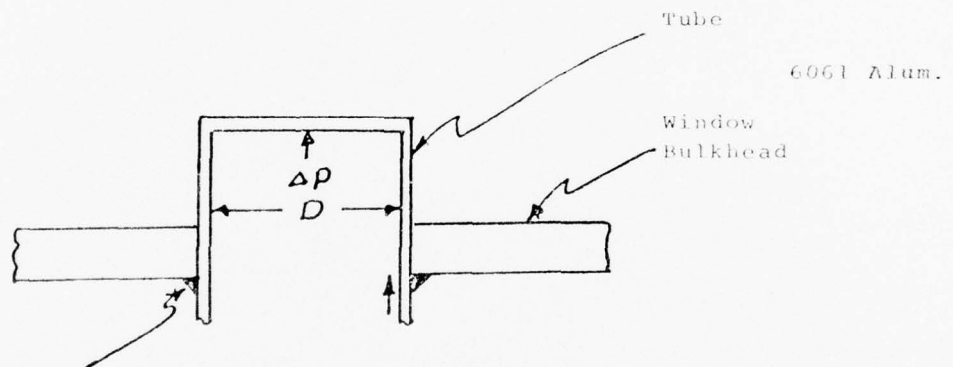
$$SF = \frac{9,000}{54} = 166$$

# CALCULATION OF SHEAR STRESS IN TUBE WELD

## Reference:

Roark, Raymond J. Formulas for Stress and Strain;  
4th Ed, McGraw-Hill Book Co; N.Y., N.Y. 1965.

The shear stress in the weld can be computed using the minimum cross sectional area of the weld and the applied load  
(Pg 334 of Ref.)



Min. Cross Section

$$\text{Shear Stress} = S_s = \frac{\text{Force}}{\text{Weld Area}} = \frac{F}{A_s}$$

$$\text{Applied Force} = F = (\Delta p) (\text{Tube Area}) = \Delta p \frac{\pi D^2}{4}$$

## STRESS IN AIRFOIL

### INTRODUCTION:

The airfoil is a NACA 0018 Section. The airfoil is constructed from two end plates, a central strut, a solid trailing edge and a 0.090 in. thick skin attached by screws to the structure. The maximum stress will occur in the screws which attach the skin or the screws which attach the airfoil to the bulkhead. The load on each set of screws is approximately the same and since the cross sectional area of the bulkhead screw is less than one-third of the skin attachment screws, a computation of the stress level in the bulkhead screw should provide the worst stress condition.

### LOADS ON AIRFOIL:

The loads on the airfoil come from three sources; (1) airfoil lift, (2) airfoil drag, (3) 10g emergency load conditions. Since the lift-drag do not occur simultaneously the maximum load can be computed and then the stress can be computed.

Airfoil lift:

$$L = \frac{1}{2} \rho V^2 S C_L$$

| Symbol | Name             | Maximum Condition     |
|--------|------------------|-----------------------|
| L      | Lift             |                       |
| $\rho$ | Density          | .07 #/ft <sup>3</sup> |
| V      | Velocity         | 200 ft/sec.           |
| S      | Surface Area     | 1.2 ft <sup>2</sup>   |
| $C_L$  | Lift Coefficient | 0.8                   |

$$L = \frac{1}{2} \cdot \frac{0.7}{32} (200)^2 (1.2) (0.8)$$

$$= 42 \text{ lbs.}$$

Airfoil Drag:

$$D = \frac{1}{2} \cdot \frac{\rho}{32} V^2 S C_D$$

$$D = \text{drag coefficient} = 0.25$$

$$D = 13 \text{ lbs.}$$

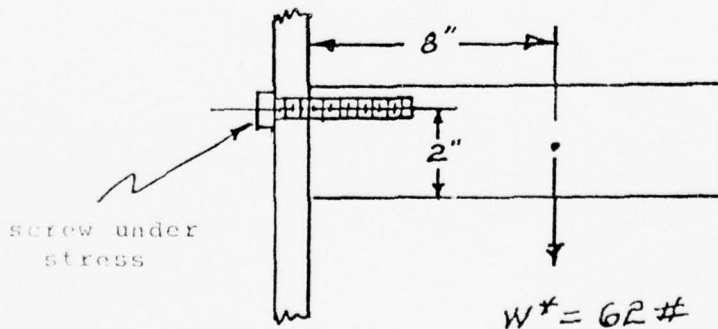
Emergency Load:

The weight airfoil was determined to be 6.2 lbs (see attached Wt Computation of Airfoil). With a 10g crash load the effective load would be 62 lbs.

The emergency load is the largest of the loads and will be used in the stress computation.

#### Stress in Bulkhead Screws

Assuming that one screw sustains the entire load under conditions as shown



$$F_T = \text{Tensil Force on Screw} = 62 \times \frac{8}{2} = 248 \#$$

The combined stress will be less than 7,000 psi. The maximum allowable stress in the screw is 60,000 psi giving a safety factor:

$$S. F. = \frac{60,000}{7,000} = 8.5$$

Stress level for 10g load:

$$\begin{aligned} \text{Wt.} &= 1.2 \times 2 \times 144 \times .090 \times 2 \times .1 = \\ &= 6.2\# \end{aligned}$$

$$\text{Eff. Load} = (10) (6.2) = 62\#$$

$$\begin{aligned} S &= \frac{(62)(8)}{2 \cdot .027} \\ &= 9185 \end{aligned}$$

$$\text{Shear Stress} = \frac{62}{.027} = 2300$$

$$\text{Combined Stress} = 9500$$

$$\text{Maximum Allowable Stress} = 60000$$

$$\text{Safety Factor} = \frac{60000}{9500} = 6.3$$

$$L = \frac{1}{2} \frac{\rho}{32} (200)^2 (1.2) (0.8)$$

$$= 42 \text{ lbs.}$$

Airfoil Drag:

$$D = \frac{1}{2} \frac{\rho}{32} v^2 S C_D$$

$$D = \text{drag coefficient} = 0.25$$

$$D = 13 \text{ lbs.}$$

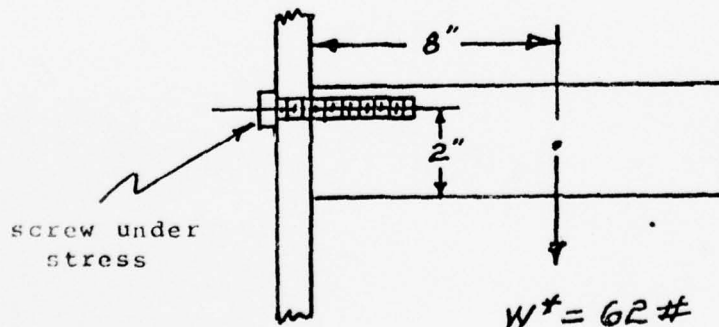
Emergency Load:

The weight airfoil was determined to be 6.2 lbs (see attached Wt Computation of Airfoil). With a 10g crash load the effective load would be 62 lbs.

The emergency load is the largest of the loads and will be used in the stress computation.

#### Stress in Bulkhead Screws

Assuming that one screw sustains the entire load under conditions as shown



$$S_T = \frac{F}{A}$$

S = screw tensile stress

A = screw area = .027 in.<sup>2</sup>

$$S_T = \frac{248}{.027} = 9200 \text{ psi}$$

$$S_s = \frac{W^*}{A}$$

S<sub>s</sub> = shear stress

$$S_s = \frac{62}{.027} = 2300 \text{ psi.}$$

$$\begin{aligned} S_c = \text{Combined Stress} &= \sqrt{S_T^2 + S_s^2} \\ &= \sqrt{9200^2 + 2300^2} \\ &= 9500 \text{ psi} \end{aligned}$$

Safety Factor:

$$SF = \frac{S_c}{S_a}$$

S<sub>a</sub> = allowable stress = 60000 psi

$$\text{S.F.} = \frac{60,000}{9,500} = 6.3$$

#### CONCLUSION

The airfoil should be capable of operating over the design conditions expected to be encountered with a safety factor of 6.3

APPENDIX E

E1-3.1

## APPENDIX E

## WALLOPS ISLAND CITATION FLIGHT RECORD

| <u>Date</u><br>(1975) | <u>Departure</u><br><u>Time</u><br>(GMT) | <u>Flight No.</u> | <u>Operation</u><br><u>Supported</u> | <u>Flight</u><br><u>Authorization</u> | <u>Flight</u><br><u>Time (hrs)</u> |
|-----------------------|--|-------------------|--------------------------------------|---------------------------------------|------------------------------------|
| 2-3                   | 1600                                     | H7502             | HEART<br>Simulation                  | C. Cullian                            | 1.8                                |
| 2-4                   | 1800                                     | F003              | FLAME<br>Mission                     | M. Rubenstein                         | 1.9                                |
| 2-10                  | 1100                                     | M002              | Holocamera                           | C. Cullian                            | 1.6                                |
| 2-21                  | 1330                                     | S002              | SAMS<br>Practice                     | Vern Plank                            | 2.7                                |
| 2-24                  | 1950                                     | S003              | SAMS                                 | Vern Plank                            | 1.9                                |
| 2-25                  | 1842                                     | H7503             | HEART                                | Vern Plank                            | 3.0                                |
| 3-5                   | 1300                                     | H7504             | HEART                                | M. Rubenstein                         | 3.1                                |
| 3-7                   | 1936                                     | S004              | SAMS                                 | Vern Plank                            | 2.6                                |
| 3-10                  | 1910                                     | S005              | SAMS                                 | Vern Plank                            | 2.1                                |
| 3-27                  | 1930                                     | F004              | FLAME                                | Dr. Cunningham                        | 1.8                                |
| 3-28                  | 1932                                     | F005              | FLAME                                | Dr. Cunningham                        | <u>1.4</u>                         |
| TOTAL FLIGHT TIME     |  |                   |                                      |                                       | 23.9                               |

SUPPLEMENT 1-4

Research Aircraft Support for  
HEART, SAMS, and FLAME at Wallops Island

1 April 1975 - 31 May 1975

by

Charles Cullian  
Stefan Steinberg

First issued as Bimonthly Report No. 4, 15 June 1975

# TABLE OF CONTENTS

|   | Page   |
|---|--------|
| 1. INTRODUCTION   | 1-4.4  |
| 2. EXTENSION OF TEST OPERATIONS<br>AT WALLOPS ISLAND  | 1-4.4  |
| 3. PROGRESS IN PRINCIPAL TASK AREAS   | 1-4.5  |
| 3.1 <u>Lease Citation N511CC</u>  | 1-4.5  |
| 3.1.1 Lease Agreement   | 1-4.5  |
| 3.1.2 Maintenance and Repair of Aircraft Systems  | 1-4.5  |
| 3.1.3 Copilot/Crew Chief Support  | 1-4.5  |
| 3.1.4 Insurance Coverage  | 1-4.5  |
| 3.1.5 Aircraft Flying Time  | 1-4.6  |
| 3.1.6 Acceptance of Citation Aircraft by Alpine<br>Aircraft Charters, Inc.                          | 1-4.6  |
| 3.2 <u>Coordination of Field Operations</u>   | 1-4.6  |
| 3.3 <u>Administer Citation Lease</u>  | 1-4.7  |
| 3.4 <u>Lease Litton LTN-51 Inertial Navigation System<br/>for Cessna Citation and P-3A Aircraft</u> | 1-4.7  |
| 3.4.1 Lease Agreements  | 1-4.7  |
| 3.4.2 Pallet Assembly   | 1-4.7  |
| 3.4.3 Emergency Battery   | 1-4.7  |
| 3.4.4 Insurance   | 1-4.8  |
| 3.4.5 Installation and Removal  | 1-4.8  |
| 3.4.6 Return of INS Units to Litton   | 1-4.8  |
| 3.5 <u>Administer INS Lease</u>   | 1-4.8  |
| 3.6 <u>Citation Crew Support for HEART and<br/>FLAME Programs</u>                                   | 1-4.9  |
| 3.6.1 Complete Consulting Agreement   | 1-4.9  |
| 3.6.2 Relocate Crew   | 1-4.9  |
| 3.6.3 Availability of MRI Program Manager and<br>Sensor Technician                                  | 1-4.9  |
| 3.6.4 Logistic Support  | 1-4.10 |
| 3.6.5 Supply Foil Replicator and Portable<br>Instrument Package                                     | 1-4.10 |
| 3.6.6 Citation Flight Hour Summary and Flight<br>Approvals  | 1-4.10 |

TABLE OF CONTENTS (continued)

|   | <i>Page</i> |
|---|-------------|
| 4. DATA ANALYSIS FOR HEART, FLAME,<br>AND SAMS                              | 1-4.10      |
| 4.1 <u>Flight Operations</u>  | 1-4.10      |
| 4.2 <u>Data Deliverables</u>  | 1-4.11      |
| 4.3 <u>Request for Transfer of Imanco Funds</u>                             | 1-4.12      |
| 5. ACTIVITIES DURING THE NEXT REPORTING<br>PERIOD                           | 1-4.12      |
| Appendix A. DNA Request for HEART Extension                                 | A1-4.1      |
| Appendix B. Litton INS Certificate of Completion<br>and Insurance Documents | B1-4.1      |
| Appendix C. Documentation of Citation Flights                               | C1-4.1      |
| Appendix D. Request for Transfer of Imanco Funds                            | D1-4.1      |

AD-A037 962

METEOROLOGY RESEARCH INC ALTADENA CALIF  
RESEARCH AIRCRAFT SUPPORT AND DATA ANALYSIS FOR THE HEART, SAMS--ETC(U)  
MAR 76 C CULLIAN, S STEINBERG  
MRI-76-FR-1405

F/G 4/2

DNA001-75-C-0040

UNCLASSIFIED

DNA-4058F

DDC USERS

2 OF 3

AD  
A037962



1. INTRODUCTION

This document reports on the progress made under Contract DNA 001-75-C-0040 and modification P00001 for the period from 1 April 1975 through 31 May 1975.

MRI is supporting DNA and AFCRL in HEART, SAMS, and FLAME hydrometeor sampling programs at Wallops Island, Virginia. This support includes an MRI instrumented and operated Cessna Citation sampling aircraft leased for the six month test period 16 November 1974 through 15 May 1975. The instrumentation includes an INS leased from Litton Aero Products and modified specifically for HEART sampling missions. MRI is also responsible for leasing and modifying the INS used in the P-3A support aircraft based at Jacksonville, Florida.

This report discusses the progress of the Citation lease, the INS lease and modification, Citation flight times, flight crew recruiting, transportation, accommodations, and coordination activities.

2. EXTENSION OF TEST OPERATIONS AT WALLOPS ISLAND

On 26 March 1975, MRI received a TWX from DNA extending the HEART program to allow missile DW8 to be launched through suitable weather. The new program cutoff date was extended to 30 April 1975 and any additional cost requirements generated by this request were to be forwarded to DNA as soon as these costs could be determined.

The TWX and the request for additional funding by MRI are included in Appendix A.

3. PROGRESS IN PRINCIPAL TASK AREAS

3.1 Lease Citation N511CC

3.1.1 Lease Agreement

The lease was negotiated with Alpine Aircraft Charters, Inc., Denver, Colorado, and guarantees exclusive use of Cessna Citation N511CC beginning on 16 November 1974 and terminating on 15 April 1975. An option to extend the lease was included to allow for the possible extension of test operations beyond the previously scheduled termination date of 31 March 1975. This option has been exercised by DNA for a one month period.

3.1.2 Maintenance and Repair of Aircraft Systems

Alpine Aircraft Charters, Inc. is maintaining the aircraft, avionics, engines, and subsystems and performing all routine maintenance inspections as per the lease agreement. Maintenance work performed on the aircraft is being scheduled so as not to impact test operations.

3.1.3 Copilot/Crew Chief Support

In accordance with the lease agreement, Alpine Aircraft Charters, Inc. is providing a full-time copilot/crew chief to support all operations during the lease period.

3.1.4 Insurance Coverage

Insurance coverage is being provided by Alpine Aircraft Charters, Inc. and the cost is included in the lease price of the aircraft. The insurance coverage is in the following amounts:

- a. Aircraft Hull Insurance - full coverage
- b. Bodily Injury, other than passenger liability - \$250,000

- c. Property Damage - \$500,000 per accident
- d. Passenger Liability - \$100,000.

The certificate of insurance was included in the previous report.

3.1.5 Aircraft Flying Time

The lease provides for unlimited usage of the aircraft during the period of the agreement.

3.1.6 Acceptance of Citation Aircraft by Alpine Aircraft Charters, Inc.

In accordance with paragraph 4 of the Aircraft Lease, on May 4, 1975, a representative from Alpine Aircraft Charters, Inc., inspected the Citation aircraft at the MRI modification facility at Cable Airport, Upland, California, to determine if all provisions had been met in returning the aircraft to its original condition following decommissioning. The aircraft was accepted as meeting contract requirements and was scheduled to be ferried to Denver. At the request of Alpine Aircraft Charters, Inc., the Citation was ferried to Sacramento, California, for required maintenance by the Cessna factory maintenance center there, and then flown to Denver. The contract was charged only for the equivalent Los Angeles to Denver flight time as noted in the Appendix.

3.2 Coordination of Field Operations

The MRI program manager is maintaining close contact with DNA and other government agencies to assure full coordination of all aircraft operations.

### 3.3        Administer Citation Lease

The MRI program manager is maintaining close contact with Alpine Aircraft Charters, Inc., to assure all lease provisions are being accomplished and all necessary maintenance is performed on the aircraft. Invoices are examined and flight time charges are verified with any conflicting items being resolved.

### 3.4        Lease Litton LTN-51 Inertial Navigation System for Cessna Citation and P-3A Aircraft

#### 3.4.1       Lease Agreements

The lease agreements negotiated with Litton Aero Products provide for full-time use of two Litton LTN-51 inertial navigation systems for the entire length of the contract period. A semi-annual (six months) lease was negotiated due to the cost savings compared to a five month period on a monthly cost basis. A copy of the lease was included in the previous report.

#### 3.4.2       Pallet Assembly

Two special pallet assemblies equipped with dual inverters and designed to adopt the Litton LTN-51 installation to aircraft such as the Citation and P-3A are included in the lease and have been installed in the aircraft.

#### 3.4.3       Emergency Battery

In accordance with the lease agreement, Litton Aero Products has supplied emergency batteries designed to fit the pallet assemblies which assures continued INS operation in the event of any temporary electrical power interruption.

#### 3.4.4 Insurance

The leases provide for insurance against all risks or loss or damage from every cause for full replacement value, as well as public liability including personal injury and property damage.

#### 3.4.5 Installation and Removal

In accordance with the lease, Litton Aero Products is providing field service support for the complete installation, checkout, and removal of the INS from the aircraft.

#### 3.4.6 Return of INS Units to Litton

On May 1, 1975, the LTN-51 inertial navigation system, including the INU, CDU, MSU, battery, and pallet assembly, was removed from the Citation aircraft at Cable Airport in Upland, California. The following day, May 2, 1975, it was delivered to Litton Aero Products in Woodland Hills, California, thus terminating the lease agreement and the insurance contract.

Litton field service removed the inertial navigation system from the Navy P-3 aircraft in Denver, Colorado, on 4 and 5 April 1975.

Both inertial navigation systems were in good condition when received at Litton's factory and letters to this effect are included in Appendix B with the certificates of insurance.

#### 3.5 Administer INS Lease

An MRI program manager is administering the provisions of the lease agreements, reviewing all invoices and resolving any conflicting items.

3.6        Citation Crew Support for HEART and FLAME Programs

3.6.1      Complete Consulting Agreement

A consulting agreement has been negotiated and a Citation rated aircraft captain will be available to support all HEART and FLAME operations, associated meetings, briefings, and alerts throughout the deployment period at Wallops Flight Center.

3.6.2      Relocate Crew

The MRI Citation support crew, consisting of an aircraft captain, copilot/crew chief, and instrument operator have been relocated to the vicinity of Wallops Flight Center and will remain there for the duration of the program.

3.6.3      Availability of MRI Program Manager and Sensor Technician

The MRI program manager and sensor service technician are available on an "as needed" basis. The program manager is monitoring the following:

- a.    Activities of the crew
- b.    Status of the Citation aircraft and its instrumentation package
- c.    Procuring and shipping consummable and crew support items as they are needed
- d.    Arranging the replacement of crew members as the need arises
- e.    Closely monitoring the packaging, shipment, and receipt of data
- f.    Handling customer's requests for unspecified services as the need arises.

#### 3.6.4 Logistic Support

All consummable supplies, spare parts, and maintenance kits required to operate the Citation aircraft and its sensor package have been procured and shipped to Wallops Flight Center to be used as needed throughout the program. An MRI program manager is in daily contact with the support crew and any needed supplies or spare parts are shipped as soon as possible. In this way, the aircraft and any part of the sensing package is available for program support in a 100 percent ready condition almost constantly.

#### 3.6.5 Supply Foil Replicator and Portable Instrument Package

One foil replicator, MRI Model 1220A, and one MRI portable instrument have been provided for the duration of the program.

#### 3.6.6 Citation Flight Hour Summary and Flight Approvals

Appendix C contains a summary of the Citation flight hours and the individual who authorized each particular flight during this reporting period.

### 4. DATA ANALYSIS FOR HEART, FLAME, AND SAMS

#### 4.1 Flight Operations

Flight operations supported by the MRI Citation during the period between 1 January and 30 April 1975 are listed in the table below.

## MRI CITATION FLIGHT OPERATIONS

| Date<br>(1975) | Operation                     | No. of<br>Missiles<br>Fired | Quick Look<br>Report<br>Issued | Preliminary<br>Data Summary<br>Issued | Final Mission<br>Data Summary<br>Issued | Status        |
|----------------|-------------------------------|-----------------------------|--------------------------------|---------------------------------------|---|---------------|
| 1-9            | SAMS                          | 2                           | 1-9                            | N/A                                   | 4-4                                     | Complete      |
| 1-20           | HEART                         | 1                           | 1-24                           | 2-14                                  | Note 1                                  | Pending info. |
| 2-4            | FLAME                         | 1                           | 2-4                            | N/A                                   | N/A                                     | Complete      |
| 3-5            | HEART                         | 0                           | N/A                            | N/A                                   | Note 2                                  | Pending info. |
| 3-7            | SAMS                          | 1                           | 3-8                            | N/A                                   | 5/16                                    | Complete      |
| 4-10           | Navajo/Cit.                   | 0                           | 4-14                           | N/A                                   | Note 3                                  | In progress   |
| 4-15           | SAMS                          | 1                           | 4-15                           | N/A                                   | Note 4                                  | In progress   |
| 4-25           | Radar/Navajo/<br>Cit. Correl. | 0                           | N/A                            | N/A                                   | Note 3                                  | In progress   |
| 4-28           | Radar/Navajo/<br>Cit. Correl. | 0                           | N/A                            | N/A                                   | Note 3                                  | In progress   |

Note 1: Awaiting final decision from AFCRL on final data format.

Note 2: Formvar photographs have been prepared for comparison with holograms. Presently awaiting instructions from AFCRL regarding interfacing with SAI.

Note 3: Processed data will be supplied to Don Takeuchi, MRI, for input to the TWCI evaluation program. AFCRL tapes will also be supplied to support radar correlations.

Note 4: Preliminary printouts of the data were supplied to A. Barnes, AFCRL, on May 8, 1975. A formal report is now being prepared.

### 4.2 Data Deliverables

Reports issued to AFCRL for the SAMS operations on January 9, March 7, and April 15 and for correlation flights on April 25 and April 28 require a digital tape to be prepared as a deliverable. The original format for the tape provided six second averages of the measured and calculated parameters, but as of May 5,

the AFCRL requirement has been respecified to be 1 second averages for all runs.

Since this notification, the MRI software has been modified accordingly and the six second tapes prepared for January 9 and March 7 have been replaced by one second tapes. All future digital tapes will provide 1 second data.

4.3        Request for Transfer of Imanco Funds

As stated in MRI Report 75R-1337, the image equipment has not been of sufficient value to warrant its use for analysis of the replicator data. As a consequence, a letter dated 1 May 1975 was sent by MRI to Captain Huston, DNA, requesting that the below line Imanco funds be transferred to labor dollars to allow MRI cloud physicists to interpret the crystal replicas for all flights including Navajo/TWCI/Radar correlation flights which involved the use of the Citation aircraft. A copy of the letter is included in Appendix D.

5.        ACTIVITIES DURING THE NEXT REPORTING PERIOD

MRI will continue to reduce and analyze data acquired during aircraft sampling missions flown from Wallops Flight Center and be responsive to any additional requests by AFCRL in relation to these activities.

APPENDIX A

DNA REQUEST FOR HEART EXTENSION

A1-4.1



MRI ATDA  
910-588-3291 V 213-830-0914  
284-085  
R 261937Z MAR 75  
FM HQ DNA WASH DC  
TO RUWOHEA/NASA WOLLOPS FLIGHT  
BUST

MRI ATDA  
910-588-3291 V 213-830-0914  
284-085  
R 261937Z MAR 75  
FM HQ DNA WASH DC  
TO RUWOHEA/NASA WOLLOPS FLIGHT CENTER WOLLOPS ISLAND VA//R BURNS//  
RUJDAHA/GENERAL ELECTRIC CO /RESO/ PO BOX 7722X 3198 CHESTNUT ST  
PHILADELPHIA PA 19101//P CLINE//  
RUCIAGA/AFCL L.G. HANSCOM FIELD BEDFORD MA//R CUNNINGHAM//  
RUCLBQA/AFETR PATRICK AFB FL//DO/CPT MUNOZ//  
RUWJREA/CELESCO INDUSTRIES INC. X XXXX 3333 HARBOR BLVD COSTA MESA CA  
92626//D HAMM//  
RUWTBDB/PARTICLE MEASURING SYSTEMS INC. X 5469 WESTERN AVEN BOULDER CO  
80301//R KNOLLENBERG//  
RUWJREA/METEOROLOGY RESEARCH INC. X 464 2WEST WOODBURY RD/ ALTADENA  
CA 91001// R DAVEY  
RUCJBBF/VW-4 WEATHER SQUADRON JACKSONVILLE FL//CDR SIRCH//  
RUEBPAA/SCIENCE APPLICATIONS INC. X 1651 OLD MEADOW RD/ MCLEAN VA  
22101//J COCKAYNE//  
RUEBPAA/METIS CORP 205 S WHITING ST/ ALEXANDRIA VA 22304//J CURRIER//  
RUWJAEA/TEXAS INSTRUMENTS INC. XPO BOX 5474X DALLAS TX 75222//R HAGEN/  
RUWJEBAS/SAMSO LOS ANGELES CA//RSSE//RSTA//

PAGE TWO RUEBDBA0654 UNCLAS  
UNCLAS DNA/SPAS SENDS  
SUBJ CLN HEART PROGRAM EXTENSION  
1. THE HYDRIMETEOR EROSION AND RECESSION TEST /HEART/ PROGRAM WILL  
BE EXTENDED TO ALLOW MISSILE DVB TO BE LAUNCHED THROUGH SUITABLE  
WEATHER. THE NEW PROGRAM CUTOFF DATE IS 30 APRIL 1975.  
2. TO ALLOW FOR PROPER FUNDING COVERAGE YOUR PROPOSAL FOR ANY  
ADDITIONAL FUNDING REQUIREMENTS GENERATED BY THIS EXTENSION SHOULD  
BE FORWARDED TO DNA AS SOON AS COSTS CAN BE DETERMINED. IT SHOULD  
BE NOTED THAT AS OF 7 APRIL 1975X THE P3A WILL BE UNAVAILABLE TO  
SUPPORT HEART AND THE C130E WILL BECOME THE PRIME RECONNAISSANCE  
AIRCRAFT.  
BT

MRI ATDA

A1-4.2

BEST AVAILABLE COPY

APPENDIX B

LITTON INS CERTIFICATE OF COMPLETION  
AND INSURANCE DOCUMENTS

B1-4.1



## AERO PRODUCTS

21050 Burtank Boulevard, Woodland Hills, California 91364 (818) 708-2701

3 June 1975  
In reply please reference:  
MEM 75-06-1046

Meteorology Research, Inc.  
464 West Woodbury Road  
Box 637  
Altadena, California 91001

Attention: Dr. Bob Davey

Subject: Purchase Order 45440-744, Certificate  
of Completion

Gentlemen:

The following LTN-51 Inertial Navigation Equipment was leased  
under the subject Purchase Order from 1 December 1974 through  
4 April 1975:

- One ea. Inertial Navigation Unit, P/N 663450
- One ea. Control Display Unit, P/N 663550
- One ea. Mode Selector Unit, P/N 663570
- One ea. Battery Unit, P/N 500012-01
- One ea. Pallet Assembly, P/N 451835-01

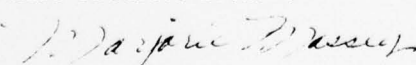
This is to certify that the subject Purchase Order is complete  
and that all of the above listed equipment has been returned  
to Litton in good condition, as of 5 April 1975.

Enclosed is the Certificate of Insurance which verifies that  
the equipment was covered for the period of the lease.

Field Engineering services were performed on 4 and 5 April  
1975, to remove the equipment from the Navy P3 aircraft in  
Denver, Colorado.

If we can be of additional service to you, please contact me  
at (213) 887-3146.

Very truly yours,  
LITTON SYSTEMS, INC.  
Aero Products Division

  
Marjorie Massey  
Contract Administrator

MM:dm  
Enclosures: Certificate of Insurance

B1-4.3

PRECEDING PAGE BLANK-NOT FILMED

## *Certificate of Self Insurance*



THIS IS TO CERTIFY that LITTON INDUSTRIES, INC. has adopted a plan known as THE LITTON SELF INSURANCE PLAN for the protection of its subsidiaries and divisions against all risks of physical loss to real and personal property, subject to a limit of \$500,000 for any one loss or occurrence.

The protection provided is subject to the terms and conditions contained in the description of THE LITTON SELF INSURANCE PLAN which includes but is not limited to the perils of fire, lightning, wind and hail, explosion, aircraft, vehicle, smoke, riot, civil commotion, vandalism, malicious mischief, flood, water damage, burglary, theft, transit risks and perils of the seas as defined in —

- (a) American Institute Time Hull Form (January 1, 1964)
- (b) American Institute Lake Time Hull Form (March 1, 1963)
- (c) American Institute Time Hull Deductible Average Clause (November 1, 1964)
- (d) Collision Clause, including Towers and Extended Towers Liability Endorsement.

THE LITTON SELF INSURANCE PLAN includes coverage of the property specifically described in the lease or the agreement between —

AERO PRODUCTS DIVISION  
Litton Systems, Inc.

and

Meteorology Research Lab  
P. O. Box 637  
Altadena, California 91001

### Description of Property

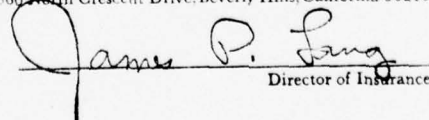
- 1 - LTN-51 Inertial Navigation System
- 1 - Battery Unit - P/N 500012-01
- 1 - Pallet Assembly - P/N 451835-01  
with 40-foot cables.

Lease Period: 12-1-74 to 4-30-75

If the above property should be deleted from coverage under THE LITTON SELF INSURANCE PLAN, ten (10) days written notice of such deletion shall be sent to the above address.

LITTON INDUSTRIES, INC.  
360 North Crescent Drive, Beverly Hills, California 90210

Date 5-22-75

  
Director of Insurance



**AERO PRODUCTS**

21050 Burbank Boulevard, Woodland Hills, California 91364 (213) 887-2731

3 June 1975  
In reply please reference:  
MEM 75-06-1045

Meterology Research, Inc.  
464 West Woodbury Road  
Box 637  
Altadena, California 91001

Attention: Dr. Bob Davey

Subject: P.O. 43389-744, Certificate of Completion

Gentlemen:

The following LTN-51 Inertial Navigation Equipment was leased under the subject Purchase Order from 5/31/74 through 1 May 1975:

- One (1) ea. Inertial Navigation Unit, P/N 663450
- One (1) ea. Control Display Unit, P/N 663550
- One (1) ea. Mode Selector Unit, P/N 663570
- One (1) ea. Battery Unit, P/N 500012-01
- One (1) ea. Pallet Assembly & Cables, P/N 452664-02

This is to certify that the subject Purchase Order is complete and that all of the above listed equipment has been returned to Litton in good condition, as of 2 May 1975.

Enclosed is the Certificate of Insurance which verifies that the equipment was covered for the period of the lease.

If we can be of additional service to you, please contact me at (213) 887-3146.

Very truly yours,

LITTON SYSTEMS, INC.  
Aero Products Division

Marjorie Massey  
Contract Administrator

MM:dm

Enclosure: Certificate of Insurance

## *Certificate of Self Insurance*



THIS IS TO CERTIFY that LITTON INDUSTRIES, INC. has adopted a plan known as THE LITTON SELF INSURANCE PLAN for the protection of its subsidiaries and divisions against all risks of physical loss to real and personal property, subject to a limit of \$500,000 for any one loss or occurrence.

The protection provided is subject to the terms and conditions contained in the description of THE LITTON SELF INSURANCE PLAN which includes but is not limited to the perils of fire, lightning, wind and hail, explosion, aircraft, vehicle, smoke, riot, civil commotion, vandalism, malicious mischief, flood, water damage, burglary, theft, transit risks and perils of the seas as defined in —

- (a) American Institute Time Hull Form (January 1, 1964)
- (b) American Institute Lake Time Hull Form (March 1, 1963)
- (c) American Institute Time Hull Deductible Average Clause (November 1, 1964)
- (d) Collision Clause, including Towers and Extended Towers Liability Endorsement.

THE LITTON SELF INSURANCE PLAN includes coverage of the property specifically described in the lease or the agreement between —

AERO PRODUCTS DIVISION  
Litton Systems, Inc.

and

Meteorology Research, Inc.  
P. O. Box 637  
Altadena, California 91001

### Description of Property

Leased LTN-51, Battery Unit and Pallet Assembly.

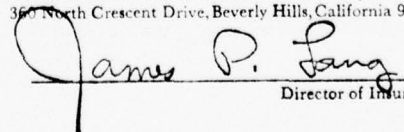
Coverage from 5/31/74 to 5/1/75.

RE: P. O. No. 43389-744

If the above property should be deleted from coverage under THE LITTON SELF INSURANCE PLAN, ten (10) days written notice of such deletion shall be sent to the above address.

LITTON INDUSTRIES, INC.  
360 North Crescent Drive, Beverly Hills, California 90210

Date December 18, 1974

  
Director of Insurance

APPENDIX C  
DOCUMENTATION OF CITATION FLIGHTS

C1-4.1

# DOCUMENTATION OF CITATION FLIGHTS

| <u>Date</u> | <u>GMT<br/>Departure<br/>Time</u> | <u>Flight<br/>No.</u> | <u>Operation<br/>Supported</u>              | <u>Flight<br/>Authorization</u> | <u>Flight<br/>Time<br/>(hrs)</u> |
|-------------|-----------------------------------|-----------------------|---|---------------------------------|----------------------------------|
| 4-2         | 1950                              | M-003                 | Holocamera                                  | R. Cunningham                   | 1.0                              |
| 4-10        | 1424                              | C-001                 | Correlation &<br>Calibration with<br>Navajo | V. Plank                        | 2.7                              |
| 4-15        | 1324                              | S-006                 | SAMS  | V. Plank                        | 2.6                              |
| 4-24        | 1535                              | C-002                 | Instrument<br>Check Flight                  | C. Cullian                      | 1.3                              |
| 4-25        | 1706                              | C-003                 | C-130 Calibra-<br>tion Flight               | R. Cunningham                   | 1.5                              |
| 4-28        | 1810                              | C-004                 | C-130/Navajo<br>Calibration Flight          | R. Cunningham                   | 1.3                              |
| 4-30        | 1425                              | N/A                   | Ferry Flight                                | C. Cullian                      | 7.3                              |
| 5-1         | 1445                              | N/A                   | Ferry Flight                                | C. Cullian                      | 2.7                              |
| 5-10        | 2015                              | N/A                   | Ferry Flight                                | C. Cullian                      | 2.7*                             |

\* Equivalent ferry time required by contract to ferry aircraft from  
Cable Airport to Denver.

APPENDIX D  
REQUEST FOR TRANSFER OF IMANCO FUNDS

May 1, 1975

Captain Robert Huston/SPAS  
Headquarters  
Defense Nuclear Agency  
Washington, D. C. 20305

Re: Contract DNA 001-75-C-0040-P0001

Dear Captain Huston:

It is requested that a modification be issued to permit the transfer of \$10,780 from the Fixed Usage charge portion to the Cost and Fee portion of the referenced contract.

This transfer of funds does not require a change in the total contract funds (see the attached schedule).

The reasons for this request are as follows:

- 1) The total number of Wallop's missile operations flown were less than originally planned, thereby leaving unused Citation Aircraft flight funds. Meteorology Research, therefore, at the direction of AFCL, flew the Citation Aircraft in support of Navajo/TWCI/Radar correlation experiments.
- 2) The cloud physics and data analyses associated with the correlation experiments do require additional funds. These funds are available in the Fixed Use charge portion of the contract under the Image Analyzer (\$10,780). These Image Analyzer funds are not required because as stated in NRI Report 75R-1337, the image equipment has not been of sufficient value to warrant use for analysis of the replicator data as called for under Task "C", Item 1.

Your early approval of this request will be appreciated. If you have questions, please contact me.

Sincerely,

METEOROLOGY RESEARCH, INC.

R. D. Wiggins  
Vice President Adm. & Finance

RDW:mhh  
enc.

D1-4.2

SUPPLEMENT NO. 2

DATA SUMMARIES

- 2-1 Data Summary MRI 75R-1325, 4 April 1975
- 2-2 Data Summary MRI 75R-1295, 14 February 1975
- 2-3 Data Summary MRI 75R-1332, 15 May 1975
- 2-4 Data Summary MRI 75R-1357, 28 August 1975
- 2-5 Data Summary MRI 75R-1358, 28 August 1975
- 2-6 Data Summary MRI 75R-1359, 28 August 1975

SUPPLEMENT 2-1

Data Summary for SAMS V Operation

9 January 1975

by

C. Cullian

First issued as MRI 75R-1325, 4 April 1975

2-1.1

## TABLE OF CONTENTS

|                          | Page   |
|--------------------------|--------|
| 1. INTRODUCTION          | 2-1.3  |
| 2. MISSION DESCRIPTION   | 2-1.3  |
| 3. EQUIPMENT OPERATION   | 2-1.3  |
| 4. REDUCED PARTICLE DATA | 2-1.3  |
| 5. AFCRL DIGITAL TAPE    | 2-1.4  |
| APPENDIX A               | A2-1.1 |
| APPENDIX B               | B2-1.1 |
| APPENDIX C               | C2-1.1 |
| APPENDIX D               | D2-1.1 |

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the SAMS operation on 9 January 1975. The data have been reviewed and processed in accordance with the procedures indicated in the 31 January letter from Dr. Barnes, AFCRL. The letter is included in Appendix A for reference.

## 2. MISSION DESCRIPTION

Two TATER vehicles were launched from Wallops Island, Virginia, at 0300 Z, 9 January 1975, as part of the SAMS V program.

The Meteorology Research, Inc. (MRI), Citation supported the test by flying post-launch radar vectored sampling runs at FL 280 and FL 250. After takeoff at 0206 Z, the Citation crew observed reasonably uniform, moderately heavy clouds before launch time. However, during the sampling runs the clouds began to break up and clear air was encountered during much of the time. By the time the Citation was in position for a third run at FL 220, the environment was virtually clear air and the crew was advised by WOCC to return to Wallops Flight Center. The Citation returned to base at 0410 Z and down loaded the sensing and data logging equipment.

## 3. EQUIPMENT OPERATION

All sensor systems were operational during the flight with no apparent anomalies.

## 4. REDUCED PARTICLE DATA

Reduced particle count data from the Citation flight are shown in Appendix B.

The data presented are pass averages of the number density

for melted equivalent diameters corresponding to each size channel of the spectrometer probes. In addition, the pass averages of the water content for each size channel for the three spectrometer probes are presented.

The total ice water content was computed using the density table shown in Appendix C. The memorandum included in Appendix C was sent to Dr. R. Cunningham, AFCRL, to confirm verbal agreement on crystal type and the corresponding size-mass relationships to be used in processing the data.

The latitude and longitude interface from the inertial navigation system was not functioning during the test runs; therefore, nominal location values of 30°N and 70°W appear throughout the printout.

#### 5. AFCRL DIGITAL TAPE

The data tape accompanying this report is in the AFCRL format, as shown in Appendix D, and provides average values for each six-second period during the sampling runs.

APPENDIX A

A2-1.1

31 January 1975

Citation/SAMS Data Required by AFRL

HQ SAMS/RSSE (Capt Pisarczyk)

1. The following information is provided for the work statement for the MRI contract, concerning the data to be provided to AFRL from the Citation for SAMS V missions.

a. AFRL needs the following:

(1) In real time while the Citation is making measurement passes, shortly before or after the mission.

(a) At least two time checks (GMT time) during flight along with deviation from WCCC time if any.

(b) Time, with remarks on the weather, on passing points L and K, the beginning and end points of the passes.

(c) Altitude of the pass. Pressure altitude with altimeter set to 29.92.

(d) General comments on the visually observed weather.

(e) When feasible for each pass, a sample count of FMS channels. This would be specified by the AFRL Field Director from the WCCC and would usually be a visual estimate of the average one second counts in channels 1 and 4 or 2 and 5 of the precipitation probe. This information will be provided on request only.

(2) In order to aid in the preparation of the 48 hour TWA, the AFRL Field Director needs by 36 hours after the shot the following:

(a) Times (GMT) of the beginning and ending of each run, the pressure altitude of the run and an indicated temperature and airspeed.

(b) Pertinent comments on the observed weather during the flight.

(c) If the local Salisbury computer can be used, a print-out of the average particle concentration per channel for each FMS probe (average or total) for each pass is desired. Particle count per channel for each pass could be supplied in lieu of the above.

(d) The degree of success of the operation of each major piece of equipment during the flight, i.e., the PMS probes, the foil, replicator and temperature probe. If there was a problem, a short statement of the nature of the problem is desired.

(3) In the longer time scale, it is requested that the crystal habit or percent of each crystal habit identified per pass be discussed with AFCL before the further processing of the PMS data tapes. For this purpose the foil and replicator data should be examined but no extensive analysis of these data are presently programmed.

(a) The catalog of shadow length to mass relationships that are used in the analysis of the PMS data should be supplied to AFCL.

(b) After crystal type of mix per pass has been agreed to by AFCL and MRI the PMS raw tape data should be transferred to a Kwajalein type tape and this tape sent to AFCL/LYC to arrive NLT 30 days after mission. Crystal habit or percent mix used for each pass should be included.

(c) A summary listing of particle concentration and IWC per pass should be provided similar in format to that in MRI report on HEART mission on 25 March 1974, report dated 23 April 1974.

ARNOLD A. BARNES, Jr., Acting Chief,  
Convective Cloud Physics Branch  
Meteorology Laboratory

Cy to: DMA (Capt R. Houston)  
MRI (Mr. R. Devey)  
SAMSO (Mr. J. Hess)  
LY (Dr. R. Cunningham)  
LYC (Mr. M. Glass)

APPENDIX B  
CITATION DATA

CITATION DATA  
1/ 5/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 3- 8-54Z STD TIME 3-13- 6Z  
START POSITION 30- 0.0N, 70- 0.0W END POSITION 30- 0.0N, 70- 0.0W  
TEMPERATURE -36.1 DEG C ALTITUDE 8556 MET TAS 101.8 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 2.3465E+07                       | 24.5 TO 34.7                    | 5.8511E+03                       | 132.0 TO 220.0                  | 1.4870E+01                       |
| 4.8 TO 6.8                      | 6.9525E+06                       | 34.7 TO 43.7                    | 1.1128E+03                       | 220.0 TO 378.0                  | 2.2457E+01                       |
| 6.8 TO 8.7                      | 1.4569E+06                       | 43.7 TO 51.8                    | 1.7985E+02                       | 308.0 TO 396.0                  | 5.4864E-01                       |
| 8.7 TO 10.6                     | 3.9029E+05                       | 51.8 TO 59.2                    | 1.9564E+02                       | 396.0 TO 484.0                  | 1.7577E-01                       |
| 10.6 TO 12.5                    | 1.3367E+06                       | 59.2 TO 66.2                    | 2.0137E+02                       | 484.0 TO 572.0                  | 5.7427E-02                       |
| 12.5 TO 14.5                    | 5.3434E+05                       | 66.2 TO 72.9                    | 2.4656E+02                       | 572.0 TO 660.0                  | 1.3351E-02                       |
| 14.5 TO 16.4                    | 6.2600E+04                       | 72.9 TO 79.3                    | 2.4019E+02                       | 660.0 TO 748.0                  | 4.9357E-03                       |
| 16.4 TO 17.9                    | 9.1442E+04                       | 79.3 TO 85.4                    | 4.0264E+02                       | 748.0 TO 836.1                  | 5.1733E-03                       |
| 17.9 TO 19.1                    | 8.0716E+04                       | 85.4 TO 92.6                    | 3.4789E+02                       | 836.1 TO 924.1                  | 8.2850E-03                       |
| 19.1 TO 20.3                    | 1.0430E+05                       | 92.6 TO 101.2                   | 4.3632E+02                       | 924.1 TO 1012.1                 | 3.0059E-03                       |
| 20.3 TO 21.5                    | 5.4993E+04                       | 101.2 TO 110.0                  | 4.1858E+02                       | 1012.1 TO 1100.1                | 0.                               |
| 21.5 TO 22.5                    | 5.1455E+04                       | 110.0 TO 118.8                  | 2.9942E+02                       | 1100.1 TO 1188.1                | 0.                               |
| 22.5 TO 23.7                    | 4.0563E+04                       | 118.8 TO 127.6                  | 1.1132E+02                       | 1188.1 TO 1276.1                | 0.                               |
| 23.7 TO 24.8                    | 6.4126E+04                       | 127.6 TO 136.4                  | 8.2212E+01                       | 1276.1 TO 1364.1                | 0.                               |

CITATION DATA  
1/ 9/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 3- 6-54Z STOP TIME 3-13- 6Z  
START POSITION 30- 0.0N, 70- 0.0W END POSITION 30- 0.0N, 70- 0.0W  
TEMPERATURE -36.1 DEG C ALTITUDE 8556 MET TAS 101.8 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 1.364E-03        | 30 TO 50                     | 8.480E-04        | 300 TO 500                   | 3.736E-03        |
| 5 TO 7                       | 1.364E-03        | 50 TO 70                     | 3.191E-04        | 500 TO 700                   | 1.904E-03        |
| 7 TO 9                       | 6.773E-04        | 70 TO 90                     | 8.385E-05        | 700 TO 900                   | 1.123E-03        |
| 9 TO 11                      | 3.544E-04        | 90 TO 110                    | 1.311E-04        | 900 TO 1100                  | 6.873E-04        |
| 11 TO 13                     | 2.097E-03        | 110 TO 130                   | 1.840E-04        | 1100 TO 1300                 | 3.896E-04        |
| 13 TO 15                     | 1.331E-03        | 130 TO 150                   | 2.929E-04        | 1300 TO 1500                 | 1.438E-04        |
| 15 TO 17                     | 2.328E-04        | 150 TO 170                   | 3.530E-04        | 1500 TO 1700                 | 7.937E-05        |
| 17 TO 19                     | 3.827E-04        | 170 TO 190                   | 7.209E-04        | 1700 TO 1900                 | 1.184E-04        |
| 19 TO 21                     | 3.099E-04        | 190 TO 210                   | 9.075E-04        | 1900 TO 2100                 | 2.502E-04        |
| 21 TO 23                     | 5.016E-04        | 210 TO 230                   | 1.781E-03        | 2100 TO 2300                 | 1.257E-04        |
| 23 TO 25                     | 3.057E-04        | 230 TO 250                   | 2.272E-03        | 2300 TO 2500                 | 0.               |
| 25 TO 27                     | 3.274E-04        | 250 TO 270                   | 2.066E-03        | 2500 TO 2700                 | 0.               |
| 27 TO 29                     | 2.929E-04        | 270 TO 290                   | 9.594E-04        | 2700 TO 2900                 | 0.               |
| 29 TO 31                     | 5.272E-04        | 290 TO 310                   | 8.715E-04        | 2900 TO 3100                 | 0.               |

AVERAGE TOTAL IWC .02971 GM/CU M IWC STANDARD DEVIATION .01590 GM/CU M

CITATION DATA  
1/ 9/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 3-25-18Z STOP TIME 3-29-41Z  
START POSITION 30- 0.0N, 70- 0.0W END POSITION 30- 0.0N, 70- 0.0W  
TEMPERATURE -29.6 DEG C ALTITUDE 7658 MET TAS 97.9 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) |
|---------------------------------|---|---------------------------------|---|---------------------------------|---|
| 2.9 TO 4.3                      | 2.1218E+07                                    | 24.5 TO 34.7                    | 9.9269E+02                                    | 132.0 TO 220.0                  | 2.5515E+01                                    |
| 4.8 TO 6.8                      | 6.7400E+06                                    | 34.7 TO 43.7                    | 2.4169E+02                                    | 220.0 TO 348.0                  | 7.0295E+00                                    |
| 6.8 TO 8.7                      | 1.4220E+06                                    | 43.7 TO 51.8                    | 7.4364E+01                                    | 308.0 TO 396.0                  | 2.1632E+00                                    |
| 8.7 TO 10.6                     | 2.7283E+05                                    | 51.8 TO 59.2                    | 6.8887E+00                                    | 396.0 TO 484.0                  | 9.1332E-01                                    |
| 10.6 TO 12.5                    | 1.4171E+06                                    | 59.2 TO 66.2                    | 9.8311E+00                                    | 484.0 TO 572.0                  | 2.5750E-01                                    |
| 12.5 TO 14.5                    | 4.4020E+05                                    | 66.2 TO 72.9                    | 1.5268E+01                                    | 572.0 TO 660.0                  | 9.7875E-02                                    |
| 14.5 TO 16.4                    | 2.2838E+04                                    | 72.9 TO 79.3                    | 5.3048E+00                                    | 660.0 TO 748.0                  | 3.5231E-02                                    |
| 16.4 TO 17.9                    | 4.5859E+04                                    | 79.3 TO 85.4                    | 3.3524E+00                                    | 748.0 TO 836.1                  | 1.2787E-02                                    |
| 17.9 TO 19.1                    | 4.3636E+04                                    | 85.4 TO 92.6                    | 4.6521E+00                                    | 836.1 TO 924.1                  | 2.7534E-03                                    |
| 19.1 TO 20.3                    | 4.9854E+04                                    | 92.6 TO 101.2                   | 3.0422E+00                                    | 924.1 TO 1012.1                 | 9.0707E-03                                    |
| 20.3 TO 21.5                    | 2.4726E+04                                    | 101.2 TO 110.0                  | 2.2754E+00                                    | 1012.1 TO 1100.1                | 0.  |
| 21.5 TO 22.6                    | 2.4463E+04                                    | 110.0 TO 118.8                  | 3.2187E+00                                    | 1100.1 TO 1188.1                | 0.  |
| 22.6 TO 23.7                    | 1.7965E+04                                    | 118.8 TO 127.6                  | 4.4146E+00                                    | 1188.1 TO 1276.1                | 0.  |
| 23.7 TO 24.8                    | 2.5956E+04                                    | 127.6 TO 136.4                  | 4.5623E+00                                    | 1276.1 TO 1364.1                | 0.  |

CITATION DATA  
1/ 9/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 3-25-18Z STOP TIME 3-29-41Z  
START POSITION 30- 0.0N, 70- 0.0W END POSITION 30- 0.0N, 70- 0.0W  
TEMPERATURE -29.6 DEG C ALTITUDE 7658 MET TAS 97.9 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 1.233E-03        | 30 TO 50                     | 1.439E-04        | 300 TO 500                   | 6.662E-03        |
| 5 TO 7                       | 1.322E-03        | 50 TO 70                     | 6.929E-05        | 500 TO 700                   | 5.951E-03        |
| 7 TO 9                       | 6.611E-04        | 70 TO 90                     | 3.467E-05        | 700 TO 900                   | 4.348E-03        |
| 9 TO 11                      | 2.477E-04        | 90 TO 110                    | 4.617E-06        | 900 TO 1100                  | 3.193E-03        |
| 11 TO 13                     | 2.224E-03        | 110 TO 130                   | 8.985E-06        | 1100 TO 1300                 | 1.815E-03        |
| 13 TO 15                     | 1.097E-03        | 130 TO 150                   | 1.220E-05        | 1300 TO 1500                 | 1.054E-03        |
| 15 TO 17                     | 8.494E-05        | 150 TO 170                   | 7.797E-06        | 1500 TO 1700                 | 5.826E-04        |
| 17 TO 19                     | 1.919E-04        | 170 TO 190                   | 5.999E-06        | 1700 TO 1900                 | 2.928E-04        |
| 19 TO 21                     | 1.690E-04        | 190 TO 210                   | 1.037E-05        | 1900 TO 2100                 | 8.579E-05        |
| 21 TO 23                     | 2.398E-04        | 210 TO 230                   | 1.242E-05        | 2100 TO 2300                 | 3.792E-04        |
| 23 TO 25                     | 1.375E-04        | 230 TO 250                   | 1.235E-05        | 2300 TO 2500                 | 0.               |
| 25 TO 27                     | 1.557E-04        | 250 TO 270                   | 2.221E-05        | 2500 TO 2700                 | 0.               |
| 27 TO 29                     | 1.297E-04        | 270 TO 290                   | 3.805E-05        | 2700 TO 2900                 | 0.               |
| 29 TO 31                     | 2.216E-04        | 290 TO 310                   | 4.836E-05        | 2900 TO 3100                 | 0.               |

AVERAGE TOTAL IWC .03279 GM/CU M IWC STANDARD DEVIATION .03932 GM/CU M

APPENDIX C

TECHNICAL MEMORANDUM

Ice crystal density ratios to be used in Citation flights  
on 9 and 20 January 1975

13 March 1975

Technical Memorandum

To: R. Cunningham (AFCRL)  
From: D. M. Takeuchi (MRI)  
Subject: Ice crystal density ratios to be used in Citation flights on  
9 and 20 January 1975.

As discussed in our phone conversation, the Citation PMS measurements taken on 9 and 20 January at Wallops Island will be reduced using the size-mass relationships for bullet rosettes.

Enclosed is a density table which will be used for computing mass for each of the 45 PMS channels. The factors represent the ratio between the mass of a particle in a particle size bin to the mass of a spherical droplet with a diameter equal to the bin size that is:

$$\text{Density Ratio} = \frac{\text{Particle Mass}}{\frac{\pi}{6} (\text{Channel Size})^3}$$

Note that a constant density ratio is assumed for particles larger than 200 microns. This is in contrast to the use of an analytic function such as that of Heymsfield and Knollenberg (1):

$$\text{mass (gm)} = 1.65 \times 10^{-5} \left( \text{length (mm)} \right)^{1.74}$$

The difference results from the colder temperatures experienced during most Citation sampling missions. Clouds in high altitude environments have been found to contain a preponderance of bullet-rosettes. Recent work by Heymsfield (2) has shown that the constant density ratio is more appropriate in such cases.

It is understood that the data will not be reduced until your written approval (signature on Table) is received here at MRI.

## References

1. Heymsfield, A. J. and R. G. Knollenberg, 1972: Properties of cirrus generating cells, J. Atmos. Sci., 29, 1358-1374.
2. Heymsfield, A. J., 1973: The Cirrus Uncinus Generating Cell and the Evolution of Cirriform Clouds, Ph.D. Thesis, U of Chicago.

DENSITY TABLE FOR CITATION PROCESSING  
OF PMS MEASUREMENTS ON 9 AND 20 JANUARY 1975  
BULLET ROSETTES

| Channel | ASP<br>Size (u) | Density<br>Ratio | CPS<br>Size (u) | Density<br>Ratio | PPS<br>Size (u) | Density<br>Ratio |
|---------|-----------------|------------------|-----------------|------------------|-----------------|------------------|
| 1       | 2               | .8986            | 20              | .8439            | 200             | .0852            |
| 2       | 4               | .8986            | 40              | .4212            | 400             | .0852            |
| 3       | 6               | .8986            | 60              | .2832            | 600             | .0852            |
| 4       | 8               | .8986            | 80              | .2147            | 800             | .0852            |
| 5       | 10              | .8986            | 100             | .1719            | 1000            | .0852            |
| 6       | 12              | .8986            | 120             | .1433            | 1200            | .0852            |
| 7       | 14              | .8986            | 140             | .1234            | 1400            | .0852            |
| 8       | 16              | .8986            | 160             | .1080            | 1600            | .0852            |
| 9       | 18              | .8986            | 180             | .0959            | 1800            | .0852            |
| 10      | 20              | .7902            | 200             | .0864            | 2000            | .0852            |
| 11      | 22              | .7191            | 220             | .0852            | 2200            | .0852            |
| 12      | 24              | .6594            | 240             | .0852            | 2400            | .0852            |
| 13      | 26              | .6091            | 260             | .0852            | 2600            | .0852            |
| 14      | 28              | .5659            | 280             | .0852            | 2800            | .0852            |
| 15      | 30              | .5288            | 300             | .0852            | 3000            | .0852            |

C2-1.4

APPROVED: *Robert M Cunningham*

DATE: 21 March 75

APPENDIX D

D2-1.1

| <u>BUF WORD<br/>NUMBER</u> | <u>PARAMETER</u>  |
|----------------------------|---|
| 1                          | 7777.   |
| 2                          | IDATE   |
| 3                          | ITIME   |
| 4                          | NSEC  |
| 5                          | TAS (m/sec)   |
| 6                          | PRES (mb)   |
| 7                          | ALT (km)  |
| 8                          | TEMP (°C)   |
| 9                          | ASP Water Content (gm/m <sup>3</sup> )                      |
| 10                         | CPS Water Content (gm/m <sup>3</sup> )                      |
| 11                         | PPS Water Content (gm/m <sup>3</sup> )                      |
| 12                         | ASP Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 13                         | CPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 14                         | PPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 15                         | ASP Total Counts  |
| 16                         | CPS Total Counts  |
| 17                         | PPS Total Counts  |
| 18                         | Latitude (Deg)  |
| 19                         | Longitude (Deg)   |
| 20                         | Not Used  |
| 21                         | ASP No. Density (No/m <sup>3</sup> )                        |
| 22                         | CPS No. Density (No/m <sup>3</sup> )                        |
| 23                         | PPS No. Density (No/m <sup>3</sup> )                        |
| 24                         | Total Water Content (gm/m <sup>3</sup> )                    |
| 25                         | Total Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> ) |
| 26                         | Total Number Density (No/m <sup>3</sup> )                   |

D2-1.3

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|         |  |
|---------|--|
| 27      | Largest particle size  |
| 28      | Average PPS particle size                                      |
| 29      | Not Used   |
| 30      | Not Used   |
| 31-75   | Number Density for size channels<br>1-45 (No/m <sup>3</sup> )  |
| 71-100  | Counts for size channels 1-45                                  |
| 121-165 | Water Content for size channels 1-45<br>(gm/m <sup>3</sup> )   |
| 166-210 | Melted equivalent diameter for size<br>channels 1-45 ( $\mu$ ) |

SUPPLEMENT 2-2

Preliminary Data Summary for HEART Operations

20 January 1975

by

C. Cullian

R. Davey

First issued as MRI 75R-1295, 14 February 1975

2-2.1

# TABLE OF CONTENTS

|  | Page   |
|--|--------|
| 1. INTRODUCTION  | 2-2.3  |
| 2. DETAILED MISSION DESCRIPTION  | 2-2.3  |
| 2.1 <u>Mission Synopsis</u>  | 2-2.3  |
| 2.2 <u>Weather Surveillance Mission</u>                                  | 2-2.4  |
| 2.3 <u>Sampling Mission</u>  | 2-2.6  |
| 3. SUMMARY OF ANOMALIES AND CORRECTIVE ACTIONS                           | 2-2.8  |
| 3.1 <u>Program Interrupt of LTN-51</u>                                   | 2-2.8  |
| 3.2 <u>Late Takeoff on Sampling Mission</u>                              | 2-2.9  |
| 3.2.1 Crew Coordination  | 2-2.9  |
| 3.2.2 INS Alignment  | 2-2.10 |
| 3.2.3 FAA Clearance Delay  | 2-2.10 |
| 3.3 <u>Formvar Replicator Transport Failure</u>                          | 2-2.10 |
| 3.4 <u>CPS Extraneous Counts</u>   | 2-2.11 |
| 3.5 <u>Storm Intercept Following</u>                                     | 2-2.11 |
| 3.6 <u>Reciprocal Storm Motion</u>                                       | 2-2.11 |
| 3.7 <u>Data Acquisition System Error Signals</u>                         | 2-1.14 |
| 3.8 <u>Data Acquisition System Fuse Failure</u>                          | 2-2.14 |
| 4. SUMMARY OF ACQUIRED DATA  | 2-2.15 |
| 4.1 <u>Particle Replication</u>  | 2-2.15 |
| 4.2 <u>Particle Count Data</u>   | 2-2.15 |
| 4.3 <u>Flight Condition Data</u>   | 2-2.15 |
| 5. SUMMARY OF METEOROLOGICAL CONDITIONS                                  | 2-2.15 |
| 6. REDUCED PARTICLE DATA COUNT   | 2-2.16 |
| 7. CONCLUSIONS   | 2-2.16 |
| APPENDIX A. HEART PRE-LAUNCH CHECKLIST FOR CITATION CAPTAIN              | A2-2.1 |
| APPENDIX B. PRELIMINARY ENVIRONMENT DATA, HEART MISSION, 20 JANUARY 1975 | B2-2.1 |

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the HEART operation on 20 January 1975. The data have not been fully analyzed and integrated and significant changes in certain values should be anticipated in future reports based upon a more comprehensive analysis. Of particular significance is the use of nominal size-mass relationships in the computation of ice water content values. These relationships may undergo substantial changes to reflect the crystal mix determined from foil replicas. Crystal typing is inherently time consuming and, therefore, could not be completed soon enough to be incorporated in this report.

## 2. DETAILED MISSION DESCRIPTION

### 2.1 Mission Synopsis

An Athena C Vehicle was launched from Wallops Island, Virginia at 2000Z, 20 January 1975, as part of the DNA HEART (Hydrometeor Erosion and Recession Test) Program.

The MRI Citation supported the test by conducting two flights into an elongated storm system situated along the East Coast from Florida to New England and extending more than 300 miles offshore.

The first Citation mission was called to acquire pre-launch sampling information along a path lying east of Norfolk, Virginia. This mission was interrupted when the Litton LTN-51 Inertial Navigation System on the Citation experienced a complete program interrupt. The Citation returned directly to Wallops Flight Center and landed at approximately 1635Z.

The takeoff for the second mission was delayed 54 minutes by a combination of equipment and personnel problems. The Citation arrived at an adjusted standby point at 2012Z and proceeded directly to the reentry region. Sampling runs were conducted from 2022Z until 2103Z at altitudes from FL350 down to FL250. The acquisition of data was seriously impaired by anomalous performance of the INS which placed the Citation west of the desired sampling location on all runs.

After the completion of the sampling, the Citation proceeded to Nantucket Island, Massachusetts, where it landed at 2152Z.

Several problems were encountered with the sensor systems during the mission. The Formvar Replicator acquired no data because of a transport malfunction. The other sensor problems did not materially affect the data acquisition.

Steps have been taken to correct all equipment malfunctions and to formalize preflight procedures to assure proper coordination of crew activities during the mission countdown.

## 2.2 Weather Surveillance Mission

A weather surveillance mission was requested by Dr. Robert Cunningham of AFCRL at about 1430Z. Clearance to operate in Warning Area W386 was given by Mr. William Lord and the aircraft was readied for departure. Engines were started at about 1500Z.

In response to a request from NASA personnel, radio checks were initiated while the Citation taxied to the runway. Some difficulty was experienced reading Wallops Plot on 6982 KHZ. Continuous radio checks by the NASA radio operator precluded the transmission of a takeoff clearance to the Citation until approximately 1515Z.

After takeoff, the Citation flew east across W-386 to about 10,000 feet, then reversed course back towards Wallops Island until above FL220. The climb was continued to above FL300 on an easterly heading. During the climb, clouds were encountered from 2,000 feet until 9,000 feet and from about FL220 upward. The upper cloud layer was relatively sparse.

After the climb, the Citation was instructed to proceed to the southeast corner of W386 and then track westward. During the transit across W386, the LTN-51 INS experienced a program interrupt which resulted in the loss of all navigation data. Since the LTN-51 is the only source of overwater position information, the Citation immediately returned to Wallops Flight Center. During the descent, clouds were encountered at all levels from FL340 down to 1,000 feet above the surface. The descent was made inbound on the 120° radial of the Snow Hill VOR starting approximately 50 miles out.

The Citation landed at about 1630Z and was immediately refueled and readied for the primary sampling mission, then scheduled for a 1900Z takeoff. Discussions were initiated with personnel from Litton Aero Products as to the cause of the INS malfunction. The system was realigned and several tests were initiated, but the operation appeared entirely normal. The Litton representatives were unable to provide any reason for the malfunction or any suggestions for corrective action.

At 1710Z, an announcement was made over the hangar loudspeakers that the launch had been rescheduled for 2030Z. On this basis, the Citation crew members left for lunch at 1720Z with the understanding that they would return at 1820 for a 1930Z takeoff.

### 2.3 Sampling Mission

The Citation crew returned at 1825Z and was informed that their desired departure time was 1830Z to support a 1930Z launch. Preflight procedures were immediately initiated including the alignment of the INS. By the expected alignment time (about 1845Z), all preparations had been completed and arrangements had been made for a flight plan to be filed by Mr. William Lord of NASA. However, the INS alignment sequence had not proceeded normally and the status was cycling in the early program stages. The sequence was restarted at about 1850Z and proceeded normally through the initial steps, but was delayed in the final alignment stages. Stabilization was finally achieved at about 1915Z and the Citation taxied for takeoff. A further minor delay for the receipt of an FAA clearance resulted in a takeoff time of 1924Z, 54 minutes after the desired departure. As a result of this delay, the launch was rescheduled for 2000Z.

Shortly after takeoff, the Formvar Replicator transport was found to be inoperative. Although the flight could have been aborted and corrective action taken, the loss of the sensor was judged less critical than the additional delay and a decision was taken to continue the flight. Communication checks during the climb indicated normal performance of all radios. A GMT timecheck was completed and coordinates were received for a revised standby point (N38-21.4, W69-45.0) on 698Z KHZ. A preliminary ETA of 2010 was given for the new standby point. Clearance information was received on VHF channels from both Wallops Plot and the FAA Centers.

After leveling at FL350 and establishing maximum cruise speed, the ETA for the standby point was revised to 2012Z. Instructions were received and acknowledged to cross the point no earlier

than 2011Z. A clearance to descent to FL250 was also received from Wallops Plot during this time period.

During the climb, clouds were encountered at all altitudes. Shortly after level off, however, the Citation entered an area of relatively clear air. The visibility at FL350 was at least five miles and an undercast with tops about 10,000 feet below was clearly visible. As the Citation continued east, clouds were again encountered at FL350, but only for a few minutes. Shortly before crossing the standby point, the Citation entered virtually clear air with unlimited visibility at FL350 and a thin haze below. The undercast was again easily seen and breaks in the undercast were evident. Further east near the reentry area, the undercast became solid, but conditions above it remained unchanged. A very thin haze existed at all altitudes with visibility ten miles or greater. No high level clouds could be seen east or south. However, an extensive cloud structure was evident to the north with identifiable layers extending up to at least FL330.

The sample mode of the INS was selected at 20:06:25 (i. e., 385 seconds after liftoff). A pierce point was received at about 2015 and all remaining storm following information was entered into the LTN-51. The system was activated to provide an intercept for the FL350 sample run. The run was started at 20:21:44 on an easterly heading, 1.5 minutes prior to the predicted intercept time. The remaining sample runs were made in accordance with the HEART operations plan (i. e., every 2,000 feet descending with three minute legs). During the runs, particle counts were noted only up to the 10 or 12 micron channels until below FL270. The 20 micron channel of the CPS showed evidence of stray counts and numerous data checks were indicated by the Data Acquisition System. Some minor problems

were experienced in following the INS intercepts because the first run had been made downwind rather than crosswind. This caused the runs to be made slightly east of the intercept points. After the completion of the FL250 run, it became evident that the Citation's position was considerably too far west. Subsequent tests of the INS software indicated that it was malfunctioning and generating erroneous intercept points.

Clearance was received from Wallops Plot to proceed to Haddock intersection and the data acquisition was terminated. Shortly after unloading the magnetic data tape, the main power fuse blew out in the Data Acquisition System.

The Citation continued north from Haddock and landed at Nantucket Island at 2152Z. After refueling, the Citation returned to Wallops Flight Center, arriving at about 0130Z, 21 January. All data were downloaded and packaged for shipment to MRI.

On 21 January, the magnetic tape was successfully duplicated and sample records were dumped. This confirmed the anomalies evidenced during the sampling.

### 3. SUMMARY OF ANOMALIES AND CORRECTIVE ACTIONS

#### 3.1 Program Interrupt of LTN-51

During the weather surveillance mission, the system warning light illuminated on the CDU and all display information disappeared. All interrogation modes were tried, but no information was displayed. The system was placed on standby and then back on align. Normal indications were evident, although the motion of the aircraft precluded realignment.

After landing, a normal alignment of the system was accomplished and all functions appeared normal in both modes.

No satisfactory explanation has been given by Litton for the abnormal performance. A replacement IMU has been received from Litton Aero Products and it operates normally in all modes. The original IMU will be returned to Litton for analysis and repair. It is significant to note that the LTN-51 on the P-3A experienced an identical failure east of Norfolk at about 1600Z. The P-3A IMU is also being returned to Litton Aero Products for evaluation.

### 3.2 Late Takeoff on Sampling Mission

#### 3.2.1 Crew Coordination

The misunderstanding on the part of the MRI crew members concerning the launch time indicates the need for improved communication between the launch control center and the Citation captain. It was anticipated that the crew would remain in the launch control room from at least T-3:00 until the beginning of the final aircraft preparation at T-2:00. This plan was precluded by the weather reconnaissance mission and the resulting INS problems. During the period when a final launch time was being determined, the crew was involved with refueling and discussing the INS malfunction with Litton. As a result, the adjustment of the launch time from 2000Z to 1930Z was not communicated. The situation was made worse by the incorrect loud-speaker announcement of a 1530 launch time.

In the future, the Citation crew must remain in the Launch Control Center from T-3:00 until they start final preflight preparations. The Citation takeoff window is extremely narrow because of fuel limitations and any delay or misunderstanding will have a direct impact on the mission.

A checklist has been prepared for the Citation captain which will preclude further problems of this type. Of particular importance is the notification of the DNA mission director at T-3:00 of the planned takeoff time based on desired arrival time at the standby point and forecast winds. Any serious misunderstanding should become immediately evident. The complete checklist is given in Appendix A.

#### 3.2.2 INS Alignment

The extended alignment is evidence of a system malfunction. The newly received IMU exhibits no alignment problems.

#### 3.2.3 FAA Clearance Delay

Although great care has been taken to coordinate the clearance requests with the FAA, some time may elapse between the final request for a specific flight path and takeoff time and the receipt of a clearance. To assure the Citation minimum impact, a preliminary clearance will be filed by the captain at T-3:00 in accordance with the preflight checklist. Revisions will be requested as required should the launch azimuth or takeoff time be changed. The final request for clearance will be accomplished by the Citation captain 30 minutes prior to the scheduled takeoff time.

#### 3.3 Formvar Replicator Transport Failure

A power lead fell off the main transport motor. The lead has been repaired and all leads to the transport and tension motors have been recrimped and tested. The replicator was successfully ground tested after the completion of the repairs.

#### 3.4 CPS Extraneous Counts

The first two channels of the Cloud Particle Spectrometer showed counts of several hundred at times when counts in all other CPS channels and corresponding ASP channels were zero. The malfunction was caused by poor alignment of the laser and associated optics. The probe has been aligned and tested and is now operating normally.

#### 3.5 Storm Intercept Following

Minor difficulties were encountered in following the intercept directions from the INS because the initial leg was oriented downwind as a result of the revised sampling point location. The completion of the turn after the second (i. e., upwind) leg placed the Citation virtually over the intercept point for the third leg and the resulting sample leg was slightly east of the intercept point. Figures 1.a and 1.b show the coordinates of the points in the middle of each sample leg. This problem will not occur under normal conditions (i. e., flying nearly south from the standby point with west winds), but the initial intercept can be offset slightly to assure a crosswind track whenever necessary. The Citation captain has been briefed about this revision in the procedure for using the storm track mode. A practice flight will be conducted on 3 February 1975 to assure proficiency.

#### 3.6 Reciprocal Storm Motion

As shown in Figures 1.a and 1.b, the INS generated intercept points on the reciprocal of the storm motion vector (i. e.,  $250^\circ$  rather than  $070^\circ$ ). This is indicative of the system malfunction which was found to be a software problem. The newly received IMU operates properly.

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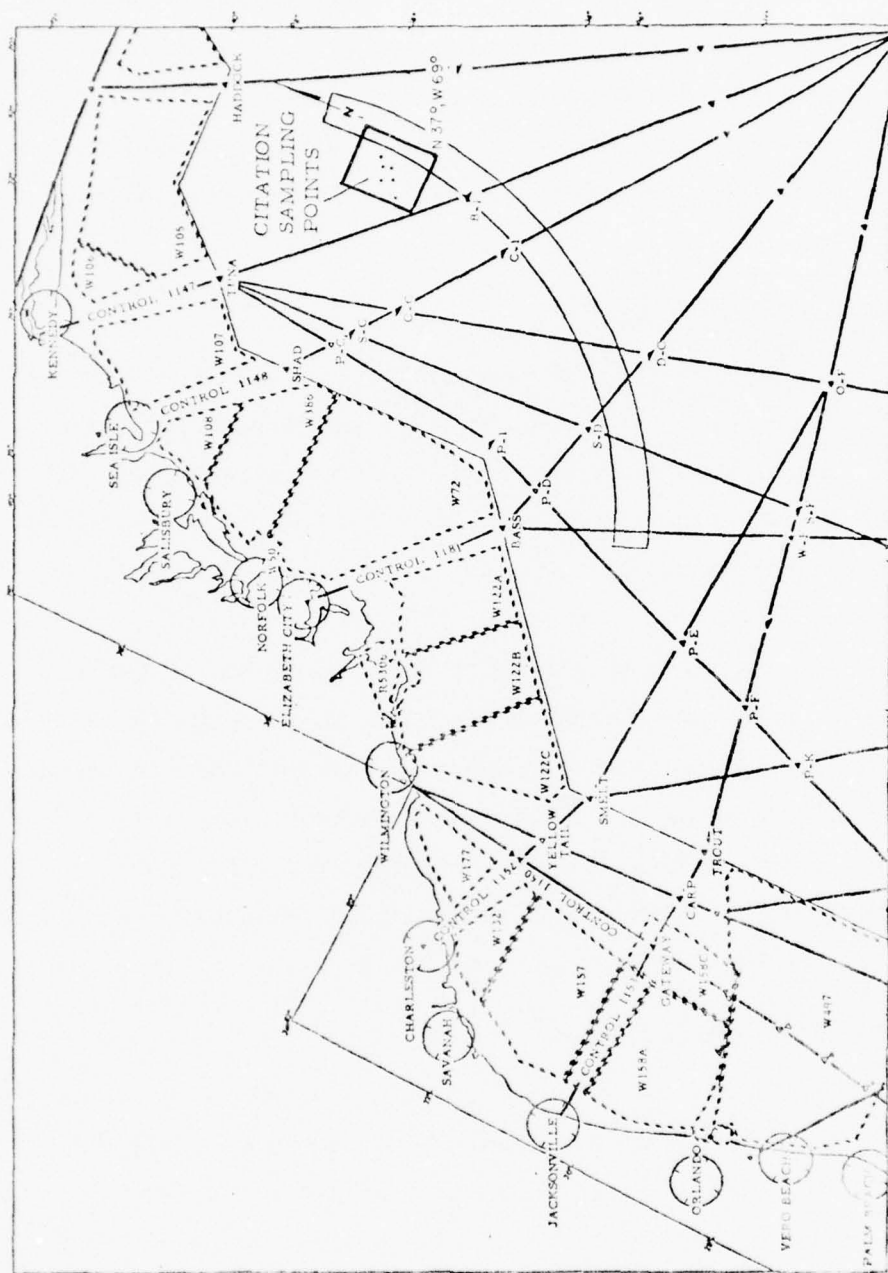


Figure 1.a. Relation of Citation sampling points to target sector.

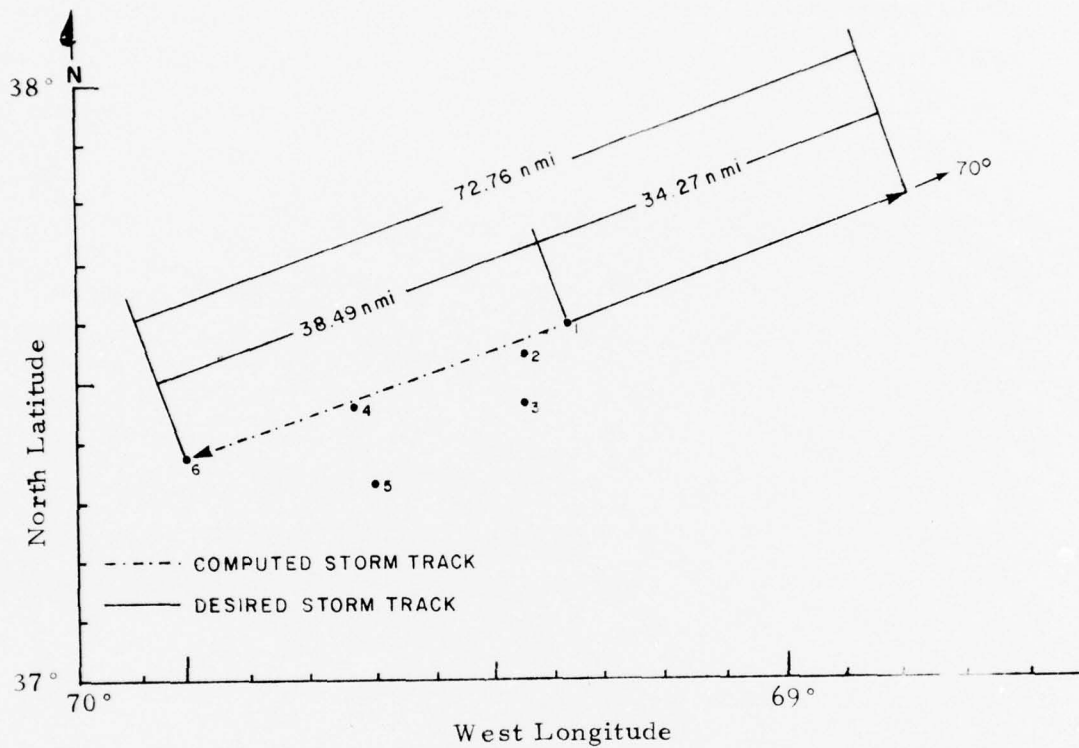


Figure 1.b. Detail of Citation sampling point locations.

The malfunction brings up an important point concerning the storm motion vector. The INS is programmed to accept a true heading and airspeed for the storm motion (i.e., movement from west to east is  $090.0^\circ$ ). The values transmitted by the mission meteorologist were in reciprocal headings. This could lead to confusion, particularly when changes are made during the mission. The procedure should require the transmission of the values that are actually to be loaded into the INS, namely the storm vector heading to 0.1 degrees (e.g.,  $070.0$ ) and the velocity in knots.

### 3.7 Data Acquisition System Error Signals

During the initial climbout, numerous data checks were generated by the Kennedy tape recorder indicating incorrect loading of data from the buffer memory. The tape was stopped, rewound, and restarted, but the error checks continued for the first 15 minutes of operation. Subsequent processing of the data tape showed numerous parity errors. The system was cleaned and tested with a different tape and showed normal operation. The most probable cause of this problem was a dirty or scratched tape.

### 3.8 Data Acquisition System Fuse Failure

The 8 ampere slow-blow main power fuse on the Data Acquisition System blew out shortly after the completion of sampling. Examination revealed that the fuse had gradually melted. The system power drain has been measured to insure that the fusing is not marginal. An appropriate replacement fuse has been installed. The replacement fuse rating has been increased to avoid gradual melting from occasional minor overloads.

#### 4. SUMMARY OF ACQUIRED DATA

##### 4.1 Particle Replication

Foil replicas were acquired at all altitudes. No Formvar replicas were acquired.

##### 4.2 Particle Count Data

Particle count data were acquired at all altitudes. The 20 and 40 micron CPS channel data are incorrect. This problem has been isolated and repaired. The data from these channels is not reflected in the following ice water contents.

##### 4.3 Flight Condition Data

Flight condition data were acquired at all altitudes.

#### 5. SUMMARY OF METEOROLOGICAL CONDITIONS

The data acquired by the Citation sensor systems indicates that the aircraft descended through very sparse, very small ice crystal haze from FL350 to FL270. Although the data were acquired far from the reentry region, visual observations at FL350 made within 15 miles of the reentry corridor indicate that similar conditions existed along the reentry path. During the descending turn after the FL350 sample run, the region east of the aircraft position had only a thin haze above the lower cloud deck. Visual observations from the P-3A during the FL240 sample run confirm this conclusion. The observer reported breaks in the clouds at FL240 during which the sun was visible above as a defined disc. Although the visual observations are hardly a substitute for proper data, in this case they may allow reasonable confidence in an ice water content profile reconstructed from the P-3A data.

## 6. REDUCED PARTICLE DATA COUNT

Reduced particle count data from the Citation are shown in Appendix B. The computed ice water content profile agrees qualitatively with visual observations, namely, that the particle content was very sparse between flight levels 350 and 270.

The data presented are pass averages of number density for each spectrometer probe size channel and the resulting total ice water content assuming bullet rosette crystals. It should be noted that the locations at which data were acquired became increasingly far removed from the desired sampling position as the sampling progressed with the final sampling level, FL250, being 72 nautical miles from the desired point (see Figure 1).

## 7. CONCLUSIONS

The sparse cloud conditions in the reentry area indicate a possible need for a last-minute environment evaluation. The Citation flight profile should be modified to allow transit through the reentry point at about T-:10 to determine cloud tops and intensity just before the launch. The Citation would then proceed to the standby point, arriving between T-:5 and T-:1.

APPENDIX A

HEART PRE-LAUNCH CHECKLIST FOR CITATION CAPTAIN

### PRE-LAUNCH CHECKLIST

T-8:00 Citation captain is notified of possible weather surveillance mission

T-6:00 to  
T-5:00 Takeoff for surveillance mission

T-4:30 Latest possible landing from surveillance mission

T-3:15 Citation captain gets probable launch azimuth from mission weather director (Dr. Cunningham of AFCRL). Citation captain prepares flight plan using forecast winds to determine takeoff and recovery times

T-3:00 Citation captain files probable flight plan with FAA Washington Center as follows:

Climb-on-course from Wallops Flight Center to Standby Point. Sampling runs in 100 nm radius of nominal pierce point from FL350 to FL250 for 40 min. Recovery at Nantucket Island, Mass.

Citation captain notifies DNA mission director (Mr. Rubenstein) of planned takeoff time

T-2:00 Citation captain receives final azimuth from mission weather director. If necessary, the flight plan will be modified and refiled with the FAA. The new planned takeoff time will be given to the DNA mission director

T-2:00 Citation systems operator initiates INS alignment performs systems preflight

T-1:30 Citation systems operator delivers aircraft and equipment status report to DNA mission director

T-1:30 Citation captain requests ATC clearance

T-1:15 to  
T-1:00 Citation departs Wallops Flight Center

T-0:15 Citation reports ETA for Standby Point to Wallops Plot

|        |  |
|--------|--|
| T-0:05 | Citation reports at Standby Point  |
| T-0:00 | Citation captain requests clearance to descend to lowest sampling altitude (usually FL250) |
| T+0:08 | Wallops Plot transmits Pierce Point to Citation  |
| T+0:11 | Wallops Plot Clears Citation to sample area  |
| T+0:16 | Citation begins sample runs  |

APPENDIX B

PRELIMINARY ENVIRONMENT DATA  
HEART MISSION, 20 JANUARY 1975

AVERAGE VALUES FOR DATA INTERVAL NUMBER 1

START TIME 20-21-44Z STOP TIME 20-24-44Z  
 TEMPERATURE -43.7 DEG C ALTITUDE 10705 MET TAS 113.7 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 7.0575E+06                     | 10 TO 30                     | 1.1180E+03                     | 100 TO 300                   | 9.7295E+00                     |
| 3 TO 5                       | 1.1688E+06                     | 30 TO 50                     | 3.6403E+02                     | 300 TO 500                   | 3.2225E+00                     |
| 5 TO 7                       | 1.7432E+06                     | 50 TO 70                     | 2.5059E+02                     | 500 TO 700                   | 2.0477E+00                     |
| 7 TO 9                       | 1.6640E+06                     | 70 TO 90                     | 2.1316E+01                     | 700 TO 900                   | 1.7920E+00                     |
| 9 TO 11                      | 1.4542E+06                     | 90 TO 110                    | 4.1202E+00                     | 900 TO 1100                  | 2.2776E-01                     |
| 11 TO 13                     | 2.5743E+04                     | 110 TO 130                   | 9.0131E+00                     | 1100 TO 1300                 | 0.                             |
| 13 TO 15                     | 1.9844E+04                     | 130 TO 150                   | 2.4282E+00                     | 1300 TO 1500                 | 2.7233E-01                     |
| 15 TO 17                     | 8.8959E+03                     | 150 TO 170                   | 0.                             | 1500 TO 1700                 | 0.                             |
| 17 TO 19                     | 1.4560E+04                     | 170 TO 190                   | 3.1861E+00                     | 1700 TO 1900                 | 0.                             |
| 19 TO 21                     | 1.6720E+04                     | 190 TO 210                   | 0.                             | 1900 TO 2100                 | 3.3337E-01                     |
| 21 TO 23                     | 2.2687E+04                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 0.                             |
| 23 TO 25                     | 1.3906E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 0.                             |
| 25 TO 27                     | 1.3667E+04                     | 250 TO 270                   | 0.                             | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 1.2801E+04                     | 270 TO 290                   | 0.                             | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 1.2233E+04                     | 290 TO 310                   | 0.                             | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .00228 GM/CU M

AVERAGE VALUES FOR DATA INTERVAL NUMBER 2

START TIME 20-26-52Z STOP TIME 20-29-52Z  
 TEMPERATURE -41.5 DEG C ALTITUDE 10095 MET TAS 109.5 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 9.0111E+06                     | 10 TO 30                     |                                | 100 TO 300                   |                                |
| 3 TO 5                       | 1.5394E+06                     | 30 TO 50                     | 8.8122E+02                     | 300 TO 500                   | 6.5480E+00                     |
| 5 TO 7                       | 1.9040E+06                     | 50 TO 70                     | 4.0999E+02                     | 500 TO 700                   | 5.0333E+00                     |
| 7 TO 9                       | 1.6068E+06                     | 70 TO 90                     | 1.4255E+02                     | 700 TO 900                   | 2.8609E+00                     |
| 9 TO 11                      | 1.5655E+06                     | 90 TO 110                    | 5.6823E+00                     | 900 TO 1100                  | 1.8544E+00                     |
| 11 TO 13                     | 5.1280E+04                     | 110 TO 130                   | 8.3489E+00                     | 1100 TO 1300                 | 7.3714E-01                     |
| 13 TO 15                     | 2.6961E+04                     | 130 TO 150                   | 3.3166E+00                     | 1300 TO 1500                 | 1.0535E+00                     |
| 15 TO 17                     | 9.9028E+03                     | 150 TO 170                   | 0.                             | 1500 TO 1700                 | 2.7428E-01                     |
| 17 TO 19                     | 1.2506E+04                     | 170 TO 190                   | 0.                             | 1700 TO 1900                 | 2.9823E-01                     |
| 19 TO 21                     | 1.4183E+04                     | 190 TO 210                   | 0.                             | 1900 TO 2100                 | 0.                             |
| 21 TO 23                     | 2.0314E+04                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 0.                             |
| 23 TO 25                     | 1.3356E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 3.8032E-01                     |
| 25 TO 27                     | 1.3595E+04                     | 250 TO 270                   | 0.                             | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 1.0436E+04                     | 270 TO 290                   | 0.                             | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 9.8339E+03                     | 290 TO 310                   | 0.                             | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .00269 GM/CU M

AVERAGE VALUES FOR DATA INTERVAL NUMBER 3

START TIME 20-32- 02 STOP TIME 20-35- 02  
 TEMPERATURE -38.1 DEG C ALTITUDE 9499 MET TAS 107.5 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 7.3982E+06                     | 10 TO 30                     |                                | 100 TO 300                   | 1.0825E+01                     |
| 3 TO 5                       | 1.1477E+06                     | 30 TO 50                     | 1.0255E+03                     | 300 TO 500                   | 3.5280E+00                     |
| 5 TO 7                       | 1.7703E+06                     | 50 TO 70                     | 3.9633E+02                     | 500 TO 700                   | 2.2388E+00                     |
| 7 TO 9                       | 1.8907E+06                     | 70 TO 90                     | 1.1020E+02                     | 700 TO 900                   | 1.1554E+00                     |
| 9 TO 11                      | 1.4082E+06                     | 90 TO 110                    | 5.7878E+00                     | 900 TO 1100                  | 1.4844E+00                     |
| 11 TO 13                     | 2.6308E+04                     | 110 TO 130                   | 0.                             | 1100 TO 1300                 | 2.7150E-01                     |
| 13 TO 15                     | 1.8196E+04                     | 130 TO 150                   | 9.7419E+00                     | 1300 TO 1500                 | 5.5833E-01                     |
| 15 TO 17                     | 1.1070E+04                     | 150 TO 170                   | 2.9176E+00                     | 1500 TO 1700                 | 0.                             |
| 17 TO 19                     | 1.4113E+04                     | 170 TO 190                   | 0.                             | 1700 TO 1900                 | 6.5084E-01                     |
| 19 TO 21                     | 1.5742E+04                     | 190 TO 210                   | 0.                             | 1900 TO 2100                 | 0.                             |
| 21 TO 23                     | 2.1537E+04                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 3.6389E-01                     |
| 23 TO 25                     | 1.4191E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 0.                             |
| 25 TO 27                     | 1.2330E+04                     | 250 TO 270                   | 0.                             | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 1.4038E+04                     | 270 TO 290                   | 0.                             | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 1.2229E+04                     | 290 TO 310                   | 0.                             | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .00276 GM/CU M

AVERAGE VALUES FOR DATA INTERVAL NUMBER 4

START TIME 20-41-56Z STOP TIME 20-44-56Z  
 TEMPERATURE -33.6 DEG C ALTITUDE 8908 MET TAS 107.0 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 7.9118E+06                     | 10 TO 30                     |                                | 100 TO 300                   | 5.4430E+02                     |
| 3 TO 5                       | 1.4950E+06                     | 30 TO 50                     | 8.6857E+03                     | 300 TO 500                   | 1.4648E+02                     |
| 5 TO 7                       | 1.7490E+06                     | 50 TO 70                     | 8.9145E+02                     | 500 TO 700                   | 5.0895E+01                     |
| 7 TO 9                       | 2.6103E+06                     | 70 TO 90                     | 3.0760E+02                     | 700 TO 900                   | 2.4721E+01                     |
| 9 TO 11                      | 8.3222E+05                     | 90 TO 110                    | 1.0352E+02                     | 900 TO 1100                  | 1.0080E+01                     |
| 11 TO 13                     | 8.7121E+04                     | 110 TO 130                   | 2.5366E+01                     | 1100 TO 1300                 | 7.1662E+00                     |
| 13 TO 15                     | 7.0297E+04                     | 130 TO 150                   | 9.9401E+00                     | 1300 TO 1500                 | 6.2350E+00                     |
| 15 TO 17                     | 5.4300E+04                     | 150 TO 170                   | 8.5483E+00                     | 1500 TO 1700                 | 4.5536E+00                     |
| 17 TO 19                     | 6.4292E+04                     | 170 TO 190                   | 0.                             | 1700 TO 1900                 | 4.2474E+00                     |
| 19 TO 21                     | 5.0588E+04                     | 190 TO 210                   | 0.                             | 1900 TO 2100                 | 7.0209E-01                     |
| 21 TO 23                     | 5.2902E+04                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 1.9311E+00                     |
| 23 TO 25                     | 3.8922E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 1.6922E+00                     |
| 25 TO 27                     | 3.8774E+04                     | 250 TO 270                   | 2.4048E+00                     | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 3.2007E+04                     | 270 TO 290                   | 4.8096E+00                     | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 3.0050E+04                     | 290 TO 310                   | 0.                             | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .01655 GM/CU M

AVERAGE VALUES FOR DATA INTERVAL NUMBER 5

START TIME 20-46-52Z STOP TIME 20-48-25Z  
 TEMPERATURE -29.6 DEG C ALTITUDE 8272 MET TAS 99.5 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 6.2594E+06                     | 10 TO 30                     | 8.8426E+03                     | 100 TO 300                   | 1.1267E+03                     |
| 3 TO 5                       | 1.0266E+06                     | 30 TO 50                     | 1.1653E+03                     | 300 TO 500                   | 2.7184E+02                     |
| 5 TO 7                       | 1.7604E+06                     | 50 TO 70                     | 3.5170E+02                     | 500 TO 700                   | 7.0307E+01                     |
| 7 TO 9                       | 2.8451E+06                     | 70 TO 90                     | 1.6658E+02                     | 700 TO 900                   | 2.6115E+01                     |
| 9 TO 11                      | 9.0998E+05                     | 90 TO 110                    | 4.4295E+01                     | 900 TO 1100                  | 1.3545E+01                     |
| 11 TO 13                     | 1.5040E+05                     | 110 TO 130                   | 2.7172E+01                     | 1100 TO 1300                 | 8.8354E+00                     |
| 13 TO 15                     | 1.4486E+05                     | 130 TO 150                   | 1.1841E+01                     | 1300 TO 1500                 | 5.8519E+00                     |
| 15 TO 17                     | 1.2838E+05                     | 150 TO 170                   | 0.                             | 1500 TO 1700                 | 5.0237E+00                     |
| 17 TO 19                     | 1.3428E+05                     | 170 TO 190                   | 6.8432E+00                     | 1700 TO 1900                 | 4.0884E+00                     |
| 19 TO 21                     | 9.3458E+04                     | 190 TO 210                   | 7.3910E+00                     | 1900 TO 2100                 | 1.4782E+00                     |
| 21 TO 23                     | 1.0321E+05                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 1.5789E+00                     |
| 23 TO 25                     | 6.5503E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 8.8961E-01                     |
| 25 TO 27                     | 6.2707E+04                     | 250 TO 270                   | 0.                             | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 4.5551E+04                     | 270 TO 290                   | 1.1186E+01                     | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 4.5443E+04                     | 290 TO 310                   | 0.02127 GM/CU M                | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .02127 GM/CU M

AVERAGE VALUES FOR DATA INTERVAL NUMBER 6

START TIME 20-56- 0Z STOP TIME 20-59- 0Z  
 TEMPERATURE -24.4 DEG C ALTITUDE 7673 MEY TAS 101.4 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/CU M) |
|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
| 1 TO 3                       | 5.8425E+06                     | 10 TO 30                     |                                | 100 TO 300                   | 1.7557E+03                     |
| 3 TO 5                       | 9.3638E+05                     | 30 TO 50                     | 1.3070E+04                     | 300 TO 500                   | 3.6479E+02                     |
| 5 TO 7                       | 1.6210E+06                     | 50 TO 70                     | 3.5615E+03                     | 500 TO 700                   | 1.1902E+02                     |
| 7 TO 9                       | 3.0985E+06                     | 70 TO 90                     | 4.9235E+02                     | 700 TO 900                   | 5.5154E+01                     |
| 9 TO 11                      | 4.0585E+05                     | 90 TO 110                    | 3.8294E+02                     | 900 TO 1100                  | 2.1452E+01                     |
| 11 TO 13                     | 7.2216E+04                     | 110 TO 130                   | 1.1564E+02                     | 1100 TO 1300                 | 1.0129E+01                     |
| 13 TO 15                     | 7.3528E+04                     | 130 TO 150                   | 6.2449E+01                     | 1300 TO 1500                 | 6.9175E+00                     |
| 15 TO 17                     | 6.5230E+04                     | 150 TO 170                   | 9.0396E+00                     | 1500 TO 1700                 | 5.1544E+00                     |
| 17 TO 19                     | 7.4573E+04                     | 170 TO 190                   | 1.2739E+01                     | 1700 TO 1900                 | 1.7107E+00                     |
| 19 TO 21                     | 5.8634E+04                     | 190 TO 210                   | 0.                             | 1900 TO 2100                 | 1.4847E+00                     |
| 21 TO 23                     | 6.0367E+04                     | 210 TO 230                   | 0.                             | 2100 TO 2300                 | 8.2292E-01                     |
| 23 TO 25                     | 4.0478E+04                     | 230 TO 250                   | 0.                             | 2300 TO 2500                 | 0.                             |
| 25 TO 27                     | 4.2560E+04                     | 250 TO 270                   | 0.                             | 2500 TO 2700                 | 0.                             |
| 27 TO 29                     | 3.1564E+04                     | 270 TO 290                   | 0.                             | 2700 TO 2900                 | 0.                             |
| 29 TO 31                     | 3.0967E+04                     | 290 TO 310                   | 0.                             | 2900 TO 3100                 | 0.                             |

AVERAGE TOTAL IWC .02422 GM/CU M

SUPPLEMENT 2-3

Data Summary for SAMS V Operation

7 March 1975

by

C. Cullian

First issued as MRI 75R-1332, 15 May 1975

2-3.1

## TABLE OF CONTENTS

|                          | Page   |
|--------------------------|--------|
| 1. INTRODUCTION          | 2-3.3  |
| 2. MISSION DESCRIPTION   | 2-3.3  |
| 3. EQUIPMENT OPERATION   | 2-3.3  |
| 4. REDUCED PARTICLE DATA | 2-3.4  |
| 5. AFCRL DIGITAL TAPE    | 2-3.4  |
| APPENDIX A               | A2-3.1 |
| APPENDIX B               | B2-3.1 |
| APPENDIX C               | C2-3.1 |

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the SAMS operation on 7 March 1975. The data have been reviewed and processed in accordance with the procedures described in Report Number MRI 75 R-1325.

## 2. MISSION DESCRIPTION

The Citation cloud physics research aircraft flew in support of a SAMS operation on 7 March 1975. The Citation departed from Wallops flight center at 1930Z and landed at 2206Z. Sampling runs were conducted at FL280 from 2120Z until 2124Z, at FL250 from 2130Z until 2140Z and at FL180 from 2151Z until 2154Z.

At FL280, the temperature was -32 degrees C. Cloud cover was continuous but varying in intensity. The airspeed during the run was between 116 and 120 KIAS.

At FL250, the temperature was -26 degrees C and cloud cover was also continuous but not uniform. The airspeed varied from 120 to 124 KIAS.

After one minute of the FL180 run, the Citation entered clear air. The temperature was -10 degrees C and the airspeed was 120 KIAS.

## 3. EQUIPMENT OPERATION

Data were collected by all sensors except the foil replicator, however, extraneous counts were recorded on the first four channels of both the CPS and ASP probes.

#### 4. REDUCED PARTICLE DATA

Reduced particle data from the Citation flight are shown in Appendix A.

The data presented are pass averages of the number density for melted equivalent diameters corresponding to each size channel of the spectrometer probes, with the exception of the first four channels of the cloud and axially scattering probes. In addition, the pass averages of the water content for these size channels are presented.

The counts for the first four channels of the ASP and CPS have been set to zero due to the anomolous counts which appeared in the raw data.

The total water content was computed using the density table shown in Appendix B. The memorandum included in this appendix was sent to Dr. R. Cunningham, AFCRL, to confirm verbal agreement on crystal type and the corresponding size-mass relationships to be used in processing the data.

#### 5. AFCRL DIGITAL TAPE

The data tape accompanying this report is in the AFCRL format, as shown in Appendix C, and provides one-second values of the data taken during each of the sampling runs.

APPENDIX A  
CITATION DATA

A2-3.1

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-27-26Z STOP TIME 19-31-20Z  
START POSITION 37-47.9N, 75-11.7W END POSITION 37-49.6N, 75-23.7W  
TEMPERATURE -35.3 DEG C ALTITUDE 8616 MET TAS 103.4 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 0.                               | 24.5 TO 34.7                    | 0.                               | 132.0 TO 220.0                  | 9.77+9E-01                       |
| 4.8 TO 6.8                      | 0.                               | 34.7 TO 43.7                    | 0.                               | 22.0 TO 308.0                   | 1.39+4E-01                       |
| 6.8 TO 8.7                      | 0.                               | 43.7 TO 51.8                    | 0.                               | 308.0 TO 396.0                  | 8.4915E-02                       |
| 8.7 TO 10.6                     | 1.1332E+06                       | 51.8 TO 59.2                    | 0.                               | 396.0 TO 484.0                  | 1.558 E-1                        |
| 10.6 TO 12.5                    | 6.4684E+05                       | 59.2 TO 66.2                    | 9.9566E+02                       | 484.0 TO 572.0                  | 8.0955E-02                       |
| 12.5 TO 14.5                    | 6.6667E+04                       | 66.2 TO 72.9                    | 3.0257E+02                       | 572.0 TO 660.0                  | 5.2714E-02                       |
| 14.5 TO 16.4                    | 1.4671E+04                       | 72.9 TO 79.3                    | 0.                               | 660.0 TO 748.0                  | 3.3072E-02                       |
| 16.4 TO 17.9                    | 2.3780E+04                       | 79.3 TO 85.4                    | 0.                               | 748.0 TO 836.0                  | 3.8245E-2                        |
| 17.9 TO 19.1                    | 2.2645E+04                       | 85.4 TO 92.6                    | 0.                               | 836.0 TO 924.0                  | 4.7209E-02                       |
| 19.1 TO 20.3                    | 2.4655E+04                       | 92.6 TO 101.2                   | 0.                               | 924.0 TO 1012.0                 | 2.8617E-02                       |
| 20.3 TO 21.5                    | 1.1745E+04                       | 101.2 TO 110.0                  | 0.                               | 1012.0 TO 1100.0                | 4.5565E-02                       |
| 21.5 TO 22.6                    | 1.6661E+04                       | 110.0 TO 118.8                  | 3.7575E-01                       | 1100.0 TO 1188.0                | 1.9414E-02                       |
| 22.6 TO 23.7                    | 1.9307E+04                       | 118.8 TO 127.6                  | 0.                               | 1188.0 TO 1276.0                | 1.710+E-02                       |
| 23.7 TO 24.8                    | 1.9327E+04                       | 127.6 TO 136.4                  | 0.                               | 1276.0 TO 1364.0                | 0.                               |

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-27-26Z STOP TIME 19-31-20Z  
START POSITION 37-47.9N, 75-11.7W END POSITION 37-49.6N, 75-23.7W  
TEMPERATURE -35.3 DEG C ALTITUDE 8616 MET TAS 103.4 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 0.               | 30 TO 50                     | 0.               | 300 TO 500                   | 2.456E-04        |
| 5 TO 7                       | 0.               | 50 TO 70                     | 0.               | 500 TO 700                   | 1.103E-04        |
| 7 TO 9                       | 0.               | 70 TO 90                     | 0.               | 700 TO 900                   | 1.771E-04        |
| 9 TO 11                      | 1.29E-03         | 90 TO 110                    | 0.               | 900 TO 1100                  | 6.117E-04        |
| 11 TO 13                     | 1.015E-03        | 110 TO 130                   | 9.10E-04         | 1100 TO 1300                 | 5.492E-04        |
| 13 TO 15                     | 1.661E-04        | 130 TO 150                   | 3.594E-04        | 1300 TO 1500                 | 5.579E-04        |
| 15 TO 17                     | 5.457E-05        | 150 TO 170                   | 0.               | 1500 TO 1700                 | 5.318E-04        |
| 17 TO 19                     | 9.952E-05        | 170 TO 190                   | 0.               | 1700 TO 1900                 | 8.757E-04        |
| 19 TO 21                     | 8.777E-05        | 190 TO 210                   | 0.               | 1900 TO 2100                 | 1.483E-03        |
| 21 TO 23                     | 1.186E-04        | 210 TO 230                   | 0.               | 2100 TO 2300                 | 1.196E-03        |
| 23 TO 25                     | 6.530E-05        | 230 TO 250                   | 0.               | 2300 TO 2500                 | 2.473E-03        |
| 25 TO 27                     | 1.261E-04        | 250 TO 270                   | 2.593E-06        | 2500 TO 2700                 | 1.340E-03        |
| 27 TO 29                     | 1.394E-04        | 270 TO 290                   | 0.               | 2700 TO 2900                 | 1.474E-03        |
| 29 TO 31                     | 1.589E-04        | 290 TO 310                   | 0.               | 2900 TO 3100                 | 0.               |

AVERAGE TOTAL IWC .01586 GM/CU M IWC STANDARD DEVIATION .02313 GM/CU M

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-40-10Z STOP TIME 19-43-34Z  
START POSITION 37-48.6N, 75-12.4W END POSITION 37-49.5N, 75-22.4W  
TEMPERATURE -28.6 DEG C ALTITUDE 7720 MET TAS 99.3 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(ND/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 0.                               | 24.5 TO 34.7                    | 1.                               | 132.1 TO 22.1                   | 9.7533E+7                        |
| 4.8 TO 6.8                      | 0.                               | 34.7 TO 43.7                    | 0.                               | 220.0 TO 308.0                  | 7.3473E-01                       |
| 6.8 TO 8.7                      | 0.                               | 43.7 TO 51.8                    | 0.                               | 308.0 TO 396.0                  | 1.4109E-01                       |
| 8.7 TO 10.5                     | 7.9347E+05                       | 51.8 TO 59.2                    | 2.5069E+00                       | 396.0 TO 484.0                  | 1.9622E-01                       |
| 10.5 TO 12.5                    | 1.1756E+06                       | 59.2 TO 66.2                    | 1.2248E+02                       | 484.0 TO 572.0                  | 6.996E-2                         |
| 12.5 TO 14.5                    | 1.1612E+05                       | 66.2 TO 72.9                    | 7.0815E+02                       | 572.0 TO 660.0                  | 6.5604E-02                       |
| 14.5 TO 16.4                    | 1.8674E+04                       | 72.9 TO 79.3                    | 2.5585E+00                       | 660.0 TO 748.0                  | 3.3339E-02                       |
| 16.4 TO 17.9                    | 2.6388E+04                       | 79.3 TO 85.4                    | 0.                               | 748.0 TO 836.1                  | 2.9569E-02                       |
| 17.9 TO 19.1                    | 2.0378E+04                       | 85.4 TO 92.6                    | 8.5974E-01                       | 836.1 TO 924.1                  | 5.9794E-2                        |
| 19.1 TO 21.3                    | 2.1510E+04                       | 92.6 TO 101.2                   | 3.8056E-01                       | 924.1 TO 1012.1                 | 2.2951E-02                       |
| 21.3 TO 21.5                    | 1.9745E+04                       | 101.2 TO 118.8                  | 0.                               | 1012.1 TO 1100.1                | 1.6728E-02                       |
| 21.5 TO 22.6                    | 1.3298E+04                       | 118.8 TO 127.6                  | 4.5785E-01                       | 1100.1 TO 1188.1                | 1.3432E-02                       |
| 22.6 TO 23.7                    | 1.4203E+04                       | 127.6 TO 136.4                  | 0.                               | 1188.1 TO 1276.1                | 5.1614E-03                       |
| 23.7 TO 24.8                    | 1.4518E+04                       | 136.4 TO 145.1                  | 0.                               | 1276.1 TO 1364.1                | 0.                               |

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-40-10Z STOP TIME 19-43-34Z  
START POSITION 37-43.6N, 75-12.4W END POSITION 37-49.5N, 75-22.4W  
TEMPERATURE -28.6 DEG C ALTITUDE 7720 MET TAS 99.3 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CC M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CC M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CC M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 0.               | 30 TO 50                     | 0.               | 300 TO 500                   | 2.451E-03        |
| 5 TO 7                       | 0.               | 50 TO 70                     | 0.               | 500 TO 700                   | 6.230E-04        |
| 7 TO 9                       | 0.               | 70 TO 90                     | 0.               | 700 TO 900                   | 2.836E-04        |
| 9 TO 11                      | 7.25E-04         | 90 TO 110                    | 1.479E-06        | 900 TO 1100                  | 7.74E-04         |
| 11 TO 13                     | 1.845E-03        | 110 TO 130                   | 1.119E-04        | 1100 TO 1300                 | 4.748E-04        |
| 13 TO 15                     | 2.893E-04        | 130 TO 150                   | 8.412E-04        | 1300 TO 1500                 | 7.067E-04        |
| 15 TO 17                     | 6.946E-05        | 150 TO 170                   | 3.760E-06        | 1500 TO 1700                 | 5.361E-04        |
| 17 TO 19                     | 1.188E-04        | 170 TO 190                   | 0.               | 1700 TO 1900                 | 6.77E-04         |
| 19 TO 21                     | 7.892E-05        | 190 TO 210                   | 2.243E-06        | 1900 TO 2100                 | 1.878E-03        |
| 21 TO 23                     | 1.035E-04        | 210 TO 230                   | 1.554E-06        | 2100 TO 2300                 | 9.594E-04        |
| 23 TO 25                     | 5.974E-05        | 230 TO 250                   | 0.               | 2300 TO 2500                 | 9.079E-04        |
| 25 TO 27                     | 6.462E-05        | 250 TO 270                   | 3.159E-06        | 2500 TO 2700                 | 9.269E-04        |
| 27 TO 29                     | 1.025E-04        | 270 TO 290                   | 0.               | 2700 TO 2900                 | 4.448E-04        |
| 29 TO 31                     | 1.194E-04        | 290 TO 310                   | 0.               | 2900 TO 3100                 | 0.               |

AVERAGE TOTAL IWC .01614 GM/CC M IWC STANDARD DEVIATION .01881 GM/CC M

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-54-50Z STOP TIME 19-57-30Z  
START POSITION 37-46.4N, 74-58.5W EVD POSITION 37-47.1N, 75- 5.1W  
TEMPERATURE -12.0 DEG C ALTITUDE 5565 MET TAS 89.2 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 0.                               | 18.9 TO 29.4                    | 0.                               | 118.8 TO 178.3                  | 1.3819E+01                       |
| 4.8 TO 6.5                      | 0.                               | 29.4 TO 38.3                    | 0.                               | 178.3 TO 232.5                  | 6.073E+00                        |
| 6.5 TO 8.7                      | 0.                               | 38.3 TO 46.7                    | 0.                               | 232.5 TO 283.3                  | 2.7275E+00                       |
| 8.7 TO 12.6                     | 1.2646E+00                       | 46.7 TO 54.7                    | 0.                               | 283.3 TO 331.5                  | 1.6427E+00                       |
| 10.6 TO 12.5                    | 8.4716E+05                       | 54.7 TO 62.3                    | 1.2569E+01                       | 331.5 TO 378.0                  | 7.9815E-01                       |
| 12.5 TO 14.5                    | 9.432E+04                        | 62.3 TO 69.7                    | 5.9141E+00                       | 378.0 TO 423.0                  | 3.6410E-01                       |
| 14.5 TO 16.4                    | 2.3282E+04                       | 69.7 TO 76.9                    | 0.                               | 423.0 TO 468.3                  | 2.7678E-01                       |
| 16.4 TO 17.9                    | 2.9672E+04                       | 76.9 TO 83.9                    | 0.                               | 468.3 TO 508.8                  | 1.3451E-01                       |
| 17.9 TO 19.1                    | 2.6175E+04                       | 83.9 TO 90.7                    | 0.                               | 508.8 TO 550.5                  | 1.6297E-01                       |
| 19.1 TO 21.3                    | 2.8823E+04                       | 90.7 TO 97.4                    | 0.                               | 550.5 TO 591.1                  | 3.5975E-02                       |
| 20.3 TO 21.5                    | 1.6239E+04                       | 97.4 TO 104.0                   | 0.                               | 591.1 TO 631.0                  | 0.                               |
| 21.5 TO 22.6                    | 2.1534E+04                       | 104.0 TO 110.5                  | 0.                               | 631.0 TO 670.0                  | 1.3703E-02                       |
| 22.6 TO 23.7                    | 1.9296E+04                       | 110.5 TO 116.8                  | 0.                               | 670.0 TO 708.6                  | 0.                               |
| 23.7 TO 24.8                    | 1.9175E+04                       | 116.8 TO 123.1                  | 0.                               | 708.6 TO 747.8                  | 0.                               |

BEST AVAILABLE COPY

CITATION DATA  
3/ 7/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-54-57Z STOP TIME 19-57-32Z  
START POSITION 37-46.4N, 74-58.5W END POSITION 37-47.1N, 75-5.0W  
TEMPERATURE -12.0 DEG C ALTITUDE 5565 MET TAS 89.2 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CM <sup>3</sup> ) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CM <sup>3</sup> ) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CM <sup>3</sup> ) |
|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| 3 TO 5                       | 0.                           | 3 TO 50                      | 0.                           | 300 TO 500                   | 1.451E-03                    |
| 5 TO 7                       | 0.                           | 50 TO 70                     | 0.                           | 500 TO 700                   | 1.517E-03                    |
| 7 TO 9                       | 0.                           | 70 TO 90                     | 0.                           | 700 TO 900                   | 1.252E-03                    |
| 9 TO 11                      | 1.145E-03                    | 90 TO 110                    | 0.                           | 900 TO 1100                  | 1.211E-03                    |
| 11 TO 13                     | 1.329E-03                    | 110 TO 130                   | 1.006E-05                    | 1200 TO 1300                 | 8.704E-04                    |
| 13 TO 15                     | 2.350E-04                    | 130 TO 150                   | 6.618E-06                    | 1300 TO 1500                 | 5.524E-04                    |
| 15 TO 17                     | 8.660E-05                    | 150 TO 170                   | 0.                           | 1500 TO 1700                 | 5.537E-04                    |
| 17 TO 19                     | 1.250E-04                    | 170 TO 190                   | 0.                           | 1700 TO 1900                 | 3.474E-04                    |
| 19 TO 21                     | 1.14E-04                     | 190 TO 210                   | 0.                           | 1900 TO 2100                 | 3.453E-04                    |
| 21 TO 23                     | 1.385E-04                    | 210 TO 230                   | 0.                           | 2100 TO 2300                 | 1.423E-04                    |
| 23 TO 25                     | 9.126E-05                    | 230 TO 250                   | 0.                           | 2300 TO 2500                 | 0.                           |
| 25 TO 27                     | 1.370E-04                    | 250 TO 270                   | 0.                           | 2500 TO 2700                 | 7.720E-05                    |
| 27 TO 29                     | 1.393E-04                    | 270 TO 290                   | 0.                           | 2700 TO 2900                 | 0.                           |
| 29 TO 31                     | 1.571E-04                    | 290 TO 310                   | 0.                           | 2900 TO 3100                 | 0.                           |

AVERAGE TOTAL IWC .01195 GM/CM<sup>3</sup> IWC STANDARD DEVIATION .01221 GM/CM<sup>3</sup>

APPENDIX B

B2-3.1



meteorology research, inc. • 464 w. woodbury rd. • altadena, calif.

Mailing address:  
Box 657, Altadena,  
Calif. 91001  
Phone: 213 791 1901

7 April 1975  
File 910 414 1493

Dr. Robert Cunningham (LY)  
Air Force Cambridge Research Labs  
Laurence G. Hanscom Field  
Bedford, Massachusetts 01730

Dear Bob:

As discussed during our phone conversation on 7 April, the Citation PMS measurements taken on March 7, 1975 will be reduced using the size-mass relationships for bullet rosettes and spatial dendrites:

Run 1 at 28 k ft, - 32C - Bullet Rosettes  
Run 2 at 25 k ft, - 26C - Bullet Rosettes  
Run 3 at 18 k ft, - 12C - Spatial Dendrites

The density ratio table of bullet rosettes used for the data on 9 and 20 January will be used for the first two runs while the enclosed ratios will be used for the spatial dendrites for Run 3. For the scattering (2 - 30  $\mu$ m) probe measurements, the ratios employed for the bullet rosettes will be used. For the cloud and precipitation probe, the density ratios are based upon the following equivalent water diameter (d) vs measured size (L) relationship.

$$d \text{ (mm)} = 0.308 L \text{ (mm)}^{0.783}$$

$$\text{Density Ratio} = 2.92 \times 10^{-2} / L \text{ (mm)}^{0.651}$$

Processing will commence after receipt of your written approval.

Sincerely,

D. M. Takeuchi  
Research Scientist

DMT:hw  
cc: Arnold Barnes-AFCRL(LYC)  
Encl.

B2-3.3

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Citation Flight on March 7, 1975

Run #1 - Bullet Rosettes

Run #2 - Bullet Rosettes

Run #3 - Spatial Dendrites

DENSITY TABLE FOR SPATIAL DENDRITES

| CPS<br>Size<br>( $\mu$ ) | Density<br>Ratio | PPS<br>Size<br>( $\mu$ ) | Density<br>Ratio |
|--------------------------|------------------|--------------------------|------------------|
| 20                       | 0.273            | 200                      | 0.0833           |
| 40                       | 0.237            | 400                      | 0.0530           |
| 60                       | 0.182            | 600                      | 0.0407           |
| 80                       | 0.151            | 800                      | 0.0338           |
| 100                      | 0.131            | 1000                     | 0.0292           |
| 120                      | 0.116            | 1200                     | 0.0259           |
| 140                      | 0.105            | 1400                     | 0.0235           |
| 160                      | 0.0963           | 1600                     | 0.0215           |
| 180                      | 0.0892           | 1800                     | 0.0199           |
| 200                      | 0.0833           | 2000                     | 0.0186           |
| 220                      | 0.0782           | 2200                     | 0.0175           |
| 240                      | 0.0739           | 2400                     | 0.0165           |
| 260                      | 0.0702           | 2600                     | 0.0157           |
| 280                      | 0.0669           | 2800                     | 0.0149           |
| 300                      | 0.0639           | 3000                     | 0.0143           |

Approved \_\_\_\_\_

Date \_\_\_\_\_

APPENDIX C

C2-3.1

| <u>BUF WORD<br/>NUMBER</u> | <u>PARAMETER</u>  |
|----------------------------|---|
| 1                          | 7777.   |
| 2                          | IDATE   |
| 3                          | ITIME   |
| 4                          | NSEC  |
| 5                          | TAS (m/sec)   |
| 6                          | PRES (mb)   |
| 7                          | ALT (km)  |
| 8                          | TEMP (°C)   |
| 9                          | ASP Water Content (gm/m <sup>3</sup> )                      |
| 10                         | CPS Water Content (gm/m <sup>3</sup> )                      |
| 11                         | PPS Water Content (gm/m <sup>3</sup> )                      |
| 12                         | ASP Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 13                         | CPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 14                         | PPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 15                         | ASP Total Counts  |
| 16                         | CPS Total Counts  |
| 17                         | PPS Total Counts  |
| 18                         | Latitude (Deg)  |
| 19                         | Longitude (Deg)   |
| 20                         | Not Used  |
| 21                         | ASP No. Density (No/m <sup>3</sup> )                        |
| 22                         | CPS No. Density (No/m <sup>3</sup> )                        |
| 23                         | PPS No. Density (No/m <sup>3</sup> )                        |
| 24                         | Total Water Content (gm/m <sup>3</sup> )                    |
| 25                         | Total Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> ) |
| 26                         | Total Number Density (No/m <sup>3</sup> )                   |

C2-3.3

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|         |   |
|---------|---|
| 27      | Largest particle size   |
| 28      | Average PPS particle size                                     |
| 29      | Not Used  |
| 30      | Not Used  |
| 31-75   | Number Density for size channels<br>1-45 (No/m <sup>3</sup> ) |
| 76-120  | Counts for size channels 1-45                                 |
| 121-165 | Water Content for size channels 1-45<br>(gm/m <sup>3</sup> )  |
| 166-210 | Melted equivalent diameter for size<br>channels 1-45 (μ)      |

SUPPLEMENT 2-4

Data Summary for SAMS V Operation

15 April 1975

by

C. Cullian

S. Thomas

First issued as MRI 75R-1357, 28 August 1975

## TABLE OF CONTENTS

|                         | Page   |
|-------------------------|--------|
| 1. INTRODUCTION         | 2-4.3  |
| 2. MISSION DESCRIPTION  | 2-4.3  |
| 3. EQUIPMENT OPERATION  | 2-4.3  |
| 4. REPORT PARTICLE DATA | 2-4.3  |
| 5. AFCRL DIGITAL TAPE   | 2-4.4  |
| APPENDIX A              | A2-4.1 |
| APPENDIX B              | B2-4.1 |
| APPENDIX C              | C2-4.1 |
| APPENDIX D              | D2-4.1 |

PRECEDING PAGE

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the SAMS operation of 15 April 1975. These data have been reviewed and processed in accordance with the procedures described in Report Number MRI 75 R-1325.

## 2. MISSION DESCRIPTION

The Citation cloud physics research aircraft flew in support of a SAMS operation on 15 April 1975. The Citation departed from Wallops Flight Center at 1324 Z and landed at 1605 Z. Sampling runs were concluded at FL 320 from 1454 Z to 1458 Z at FL 290 from 1507 Z to 1510 Z, at FL 250 from 1518 Z to 1521 Z.

At FL 320, the temperature was -40 degrees C, and airspeed during the run varied from 128 to 132 KIAS.

At FL 290, the temperature was -33 degrees C, and airspeed during the run varied from 123 to 127 KIAS.

At FL 250 the temperature was -25 degrees C, and airspeed during the run varied from 124 to 128 KIAS.

All runs were made in heavy clouds and moderate to heavy icing. Turbulence was observed at all levels.

## 3. EQUIPMENT OPERATION

Data were collected by all sensors except the formvar film, due to heavy icing at the probe inlet. The foil replicator operated at FL 320 and FL 250. While the holocamera operated at all levels, it was not monitored by the BMS, therefore no firing times are available.

## 4. REDUCED PARTICLE DATA

Reduced particle data from the Citation flight are shown in Appendix A.

The data presented are pass averages of the number density for melted equivalent diameters corresponding to each size channel of the spectrometer probes. In addition, the pass averages of the water content for these size channels are presented.

Due to rapid descent the probe mirrors/windows clouded when their temperature fell below the dew point. This condition then existed throughout pass number two, FL 290, and pass number three, FL 250, and rendered the data unsuitable for processing. Information regarding this condition is presented in Appendix B.

The total water content was computed using the density table shown in Appendix C, as stipulated in the conversation of 3 May 1975 between Dr. A. Heymsfield and Dr. R. Cunningham.

#### 5. AFCRL DIGITAL TAPE

The data tape accompanying this report is in AFCRL format, as shown in Appendix D, and provides one-second values of the data taken during sampling run number one.

APPENDIX A

A2-4.1

CITATION DATA  
4/15/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 14-54-46Z STOP TIME 14-57-36Z  
START POSITION 37-49.2N, 75-12.0W END POSITION 37-50.2N, 75-23.9W  
TEMPERATURE -40.4 DEG C ALTITUDE 9900 MET TAS 115.0 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 3.5737E+04                       | 24.5 TO 34.7                    | 1.7142E+05                       | 132.0 TO 220.0                  | 2.9583E+01                       |
| 4.8 TO 6.8                      | 4.0417E+04                       | 34.7 TO 43.7                    | 6.1673E+04                       | 220.0 TO 308.0                  | 7.2097E+00                       |
| 6.8 TO 8.7                      | 4.1704E+04                       | 43.7 TO 51.8                    | 5.1301E+01                       | 308.0 TO 396.0                  | 2.2584E+00                       |
| 8.7 TO 10.6                     | 4.9276E+04                       | 51.8 TO 59.2                    | 1.4335E+01                       | 396.0 TO 484.0                  | 6.3292E-01                       |
| 10.6 TO 12.5                    | 4.6870E+04                       | 59.2 TO 66.2                    | 4.3685E+01                       | 484.0 TO 572.0                  | 2.3407E-01                       |
| 12.5 TO 14.5                    | 3.9094E+04                       | 66.2 TO 72.9                    | 4.2023E+01                       | 572.0 TO 660.0                  | 7.3558E-02                       |
| 14.5 TO 16.4                    | 3.0803E+04                       | 72.9 TO 79.3                    | 1.3262E+00                       | 660.0 TO 748.0                  | 6.5130E-03                       |
| 16.4 TO 17.9                    | 3.2290E+04                       | 79.3 TO 85.4                    | 0.                               | 748.0 TO 836.1                  | 6.5442E-03                       |
| 17.9 TO 19.1                    | 3.0991E+04                       | 85.4 TO 92.6                    | 4.3313E-01                       | 836.1 TO 924.1                  | 3.4792E-03                       |
| 19.1 TO 20.3                    | 2.7865E+04                       | 92.6 TO 101.2                   | 1.2248E+00                       | 924.1 TO 1012.1                 | 0.                               |
| 20.3 TO 21.5                    | 2.8214E+04                       | 101.2 TO 110.0                  | 0.                               | 1012.1 TO 1100.1                | 0.                               |
| 21.5 TO 22.6                    | 2.7765E+04                       | 110.0 TO 118.8                  | 0.                               | 1100.1 TO 1188.1                | 0.                               |
| 22.6 TO 23.7                    | 2.8477E+04                       | 118.8 TO 127.6                  | 0.                               | 1188.1 TO 1276.1                | 0.                               |
| 23.7 TO 24.8                    | 2.9103E+04                       | 127.6 TO 136.4                  | 0.                               | 1276.1 TO 1364.1                | 0.                               |

CITATION DATA  
4/15/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 14-54-46Z STOP TIME 14-57-36Z  
START POSITION 37-49.2N, 75-12.0W END POSITION 37-50.2N, 75-23.9W  
TEMPERATURE -43.4 DEG C ALTITUDE 9900 MET TAS 115.0 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 2.077E-06        | 30 TO 50                     | 2.484E-02        | 300 TO 500                   | 7.458E-03        |
| 5 TO 7                       | 7.928E-06        | 50 TO 70                     | 1.768E-02        | 500 TO 700                   | 6.114E-03        |
| 7 TO 9                       | 1.939E-05        | 70 TO 90                     | 2.392E-05        | 700 TO 900                   | 4.560E-03        |
| 9 TO 11                      | 4.473E-05        | 90 TO 110                    | 9.621E-06        | 900 TO 1100                  | 2.485E-03        |
| 11 TO 13                     | 7.355E-05        | 110 TO 130                   | 3.993E-05        | 1100 TO 1300                 | 1.384E-03        |
| 13 TO 15                     | 9.741E-05        | 130 TO 150                   | 4.942E-05        | 1300 TO 1500                 | 7.924E-04        |
| 15 TO 17                     | 1.146E-04        | 150 TO 170                   | 1.949E-06        | 1500 TO 1700                 | 1.047E-04        |
| 17 TO 19                     | 1.351E-04        | 170 TO 190                   | 0.               | 1700 TO 1900                 | 1.521E-04        |
| 19 TO 21                     | 1.200E-04        | 190 TO 210                   | 1.130E-06        | 1900 TO 2100                 | 1.093E-04        |
| 21 TO 23                     | 1.340E-04        | 210 TO 230                   | 5.000E-06        | 2100 TO 2300                 | 0.               |
| 23 TO 25                     | 1.569E-04        | 230 TO 250                   | 0.               | 2300 TO 2500                 | 0.               |
| 25 TO 27                     | 1.767E-04        | 250 TO 270                   | 0.               | 2500 TO 2700                 | 0.               |
| 27 TO 29                     | 2.056E-04        | 270 TO 290                   | 0.               | 2700 TO 2900                 | 0.               |
| 29 TO 31                     | 2.310E-04        | 290 TO 310                   | 0.               | 2900 TO 3100                 | 0.               |

AVERAGE TOTAL IWC .06722 GM/CU M IWC STANDARD DEVIATION .04103 GM/CU M

APPENDIX B

B2-4.1



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meteorology research, inc. • 464 w. woodbury rd. • altadena, calif.

Mailing address  
Box 537, Altadena,  
Calif. 91001  
Phone 213 791 1961

3 July 1975  
910 424 1493

Dr. Robert Cunningham (LYC)  
Air Force Cambridge Research Labs  
Laurence G. Hanscom Field  
Bedford, Massachusetts 01730

Dear Bob:

Chuck Cullian asked me to review PMS data taken by the Citation off the coast of Wallops Island on 15 April 1975. The aircraft made three passes, the first initiating at 32.0 k ft, the second after descending to 29.0 k ft, then the third at 25.0 k ft. Data for Pass 1 looks quite acceptable. Data from the descent from level (1) to level (2) looks acceptable until 29.4 k ft. After this time, it is apparent that condensation occurred on the lenses of the probe, reducing the light level and causing extremely high, erroneous counts. This condensate began vaporizing *due to heat from the heaters* at the beginning of Pass 2 but was still partially obscuring the light level, causing erroneous counts, through to the end of the pass.

Additional condensate formed on the lenses during the descent between levels (2) and (3). This condensation was apparently very severe during Pass 3, causing very high, erroneous counts.

The net result of my review of the data was that Pass 1 data is acceptable but data for the last two passes is unusable. Chuck mentioned that you would like a data tape for all three passes, but I believe that it would be a completely useless effort except for Pass 1.

Please advise us on this matter.

Sincerely,

Andy

Andrew J. Heymsfield  
Research Scientist

AJH:hw

APPENDIX C

C2-4.1

DENSITY TABLE FOR CITATION PROCESSING  
OF PMS MEASUREMENTS ON 9 AND 20 JANUARY 1975  
BULLET ROSETTES

| Channel | ASP<br>Size (u) | Density<br>Ratio | CPS<br>Size (u) | Density<br>Ratio | PPS<br>Size (u) | Density<br>Ratio |
|---------|-----------------|------------------|-----------------|------------------|-----------------|------------------|
| 1       | 2               | .8986            | 20              | .8439            | 200             | .0852            |
| 2       | 4               | .8986            | 40              | .4219            | 400             | .0852            |
| 3       | 6               | .8986            | 60              | .2832            | 600             | .0852            |
| 4       | 8               | .8986            | 80              | .2147            | 800             | .0852            |
| 5       | 10              | .8986            | 100             | .1719            | 1000            | .0852            |
| 6       | 12              | .8986            | 120             | .1433            | 1200            | .0852            |
| 7       | 14              | .8986            | 140             | .1234            | 1400            | .0852            |
| 8       | 16              | .8986            | 160             | .1080            | 1600            | .0852            |
| 9       | 18              | .8986            | 180             | .0959            | 1800            | .0852            |
| 10      | 20              | .7902            | 200             | .0864            | 2000            | .0852            |
| 11      | 22              | .7191            | 220             | .0852            | 2200            | .0852            |
| 12      | 24              | .64              | 240             | .0852            | 2400            | .0852            |
| 13      | 26              | .5991            | 260             | .0852            | 2600            | .0852            |
| 14      | 28              | .5559            | 280             | .0852            | 2800            | .0852            |
| 15      | 30              | .5000            | 300             | .0852            | 3000            | .0852            |

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DA 21/Jan 75

APPENDIX D

D2-4.1

| <u>BUF WORD<br/>NUMBER</u> | <u>PARAMETER</u>  |
|----------------------------|---|
| 1                          | 7777.   |
| 2                          | IDATE   |
| 3                          | ITIME   |
| 4                          | NSEC  |
| 5                          | TAS (m/sec)   |
| 6                          | PRES (mb)   |
| 7                          | ALT (km)  |
| 8                          | TEMP (°C)   |
| 9                          | ASP Water Content (gm/m <sup>3</sup> )                      |
| 10                         | CPS Water Content (gm/m <sup>3</sup> )                      |
| 11                         | PPS Water Content (gm/m <sup>3</sup> )                      |
| 12                         | ASP Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 13                         | CPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 14                         | PPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 15                         | ASP Total Counts  |
| 16                         | CPS Total Counts  |
| 17                         | PPS Total Counts  |
| 18                         | Latitude (Deg)  |
| 19                         | Longitude (Deg)   |
| 20                         | Not Used  |
| 21                         | ASP No. Density (No/m <sup>3</sup> )                        |
| 22                         | CPS No. Density (No/m <sup>3</sup> )                        |
| 23                         | PPS No. Density (No/m <sup>3</sup> )                        |
| 24                         | Total Water Content (gm/m <sup>3</sup> )                    |
| 25                         | Total Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> ) |
| 26                         | Total Number Density (No/m <sup>3</sup> )                   |

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RESEARCH AIRCRAFT SUPPORT AND DATA ANALYSIS FOR THE HEART, SAMS--ETC(U)  
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|         |   |
|---------|---|
| 27      | Largest particle size   |
| 28      | Average PPS particle size                                     |
| 29      | Not Used  |
| 30      | Not Used  |
| 31-75   | Number Density for size channels<br>1-45 (No/m <sup>3</sup> ) |
| 71-100  | Counts for size channels 1-45                                 |
| 121-165 | Water Content for size channels 1-45<br>(gm/m <sup>3</sup> )  |
| 166-210 | Melted equivalent diameter for size<br>channels 1-45 (μ)      |

SUPPLEMENT 2-5

Data Summary for Correlation Operation

15 April 1975

by

C. Cullian

S. Thomas

First issued as MRI 75R-1358, 28 August 1975

2-5.1

## TABLE OF CONTENTS

|                          | Page   |
|--------------------------|--------|
| 1. INTRODUCTION          | 2-5.3  |
| 2. MISSION DESCRIPTION   | 2-5.3  |
| 3. EQUIPMENT OPERATION   | 2-5.3  |
| 4. REDUCED PARTICLE DATA | 2-5.3  |
| 5. AFCRL DIGITAL TAPE    | 2-5.4  |
| APPENDIX A               | A2-5.1 |
| APPENDIX B               | B2-5.1 |
| APPENDIX C               | C2-5.1 |

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the correlation operation on 25 April 1975. After review the data have been processed in accordance with the procedures set forth in Report Number MRI 75 R-1325.

## 2. MISSION DESCRIPTION

The Citation cloud physics research aircraft flew in support of a correlation operation on 25 April 1975. The Citation departed from Wallops Flight Center at 1905 Z and landed at approximately 2040 Z.

A sampling run was conducted at FL 180 from 2008 Z to 2018 Z at a temperature of  $-7^{\circ}\text{C}$  and airspeed between 118 and 122 KIAS. Cloud cover varied in intensity, but was continuous.

## 3. EQUIPMENT OPERATION

All sensors were functional and collected data. However, the Formvar replicator had to be reset, due to jamming which occurred approximately 5 minutes into the run.

## 4. REDUCED PARTICLE DATA

Reduced particle data from the Citation flight are shown in Appendix A.

The data presented are pass averages of the number density for melted equivalent diameters corresponding to each size channel of the spectrometer probes. Additionally, the pass averages of the water content for these size channels are presented.

The total water content was computed using the density table shown in Appendix B. The memorandum included in this appendix confirms the verbal agreement on crystal type and the corresponding size-mass relationships to be used in processing the data.

5. AFCRL DIGITAL TAPE

The data tape accompanying this report is in the AFCRL format, as shown in Appendix C, and provides one-second values of data taken during the sampling pass.

APPENDIX A

A2-5.1

CITATION DATA  
4/25/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 20-8-14Z STOP TIME 20-18-34Z  
START POSITION 37-48.5N, 75-0.0W END POSITION 37-51.0N, 75-24.3W  
TEMPERATURE -7.2 DEG C ALTITUDE 5525 MET TAS 84.6 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 2.9 TO 4.8                      | 1.3866E+04                       | 18.9 TO 29.4                    | 5.2804E+03                       | 118.8 TO 178.3                  | 3.3010E+01                       |
| 4.8 TO 6.8                      | 1.4151E+04                       | 29.4 TO 38.3                    | 1.4840E+03                       | 178.3 TO 232.5                  | 2.719+E+01                       |
| 6.8 TO 8.7                      | 1.3325E+04                       | 38.3 TO 46.7                    | 2.1413E+02                       | 232.5 TO 283.3                  | 2.1193E+01                       |
| 8.7 TO 10.6                     | 1.2105E+04                       | 46.7 TO 54.7                    | 1.2071E+02                       | 283.3 TO 331.5                  | 1.5011E+01                       |
| 10.6 TO 12.5                    | 1.0063E+04                       | 54.7 TO 62.3                    | 7.6611E+01                       | 331.5 TO 378.0                  | 9.3133E+00                       |
| 12.5 TO 14.5                    | 9.5912E+03                       | 62.3 TO 69.7                    | 5.7222E+01                       | 378.0 TO 423.0                  | 5.4430E+00                       |
| 14.5 TO 16.4                    | 7.5633E+03                       | 69.7 TO 76.9                    | 1.9274E+01                       | 423.0 TO 466.3                  | 2.9176E+00                       |
| 16.4 TO 17.9                    | 9.4723E+03                       | 76.9 TO 83.9                    | 7.8243E+00                       | 466.3 TO 508.8                  | 1.3469E+00                       |
| 17.9 TO 19.1                    | 1.0425E+04                       | 83.9 TO 90.7                    | 9.5942E+00                       | 508.8 TO 550.5                  | 7.9860E-01                       |
| 19.1 TO 20.3                    | 1.0353E+04                       | 90.7 TO 97.4                    | 7.3462E+00                       | 550.5 TO 591.1                  | 4.7015E-01                       |
| 20.3 TO 21.5                    | 9.6618E+03                       | 97.4 TO 104.0                   | 6.2834E+00                       | 591.1 TO 631.0                  | 2.7198E-01                       |
| 21.5 TO 22.6                    | 9.0490E+03                       | 104.0 TO 110.5                  | 3.3050E+00                       | 631.0 TO 670.0                  | 1.6687E-01                       |
| 22.6 TO 23.7                    | 8.4691E+03                       | 110.5 TO 116.8                  | 2.1719E+00                       | 670.0 TO 708.6                  | 1.0507E-01                       |
| 23.7 TO 24.8                    | 9.9701E+03                       | 116.8 TO 123.1                  | 9.4373E-01                       | 708.6 TO 747.8                  | 3.0152E-02                       |

CITATION DATA  
4/25/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 20- 8-14Z STOP TIME 20-18-34Z  
START POSITION 37-48.5N, 75- 0.0W END POSITION 37-51.1N, 75-24.3W  
TEMPERATURE -7.2 DEG C ALTITUDE 5525 MET TAS 84.6 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 8.058E-07        | 30 TO 50                     | 4.409E-04        | 300 TO 500                   | 3.489E-03        |
| 5 TO 7                       | 2.776E-06        | 50 TO 70                     | 2.726E-04        | 500 TO 700                   | 6.785E-03        |
| 7 TO 9                       | 6.195E-06        | 70 TO 90                     | 1.027E-04        | 700 TO 900                   | 9.751E-03        |
| 9 TO 11                      | 1.099E-05        | 90 TO 110                    | 6.592E-05        | 900 TO 1100                  | 1.106E-02        |
| 11 TO 13                     | 1.579E-05        | 110 TO 130                   | 6.135E-05        | 1100 TO 1300                 | 1.016E-02        |
| 13 TO 15                     | 2.390E-05        | 130 TO 150                   | 6.395E-05        | 1300 TO 1500                 | 8.257E-03        |
| 15 TO 17                     | 2.813E-05        | 150 TO 170                   | 2.862E-05        | 1500 TO 1700                 | 5.837E-03        |
| 17 TO 19                     | 3.964E-05        | 170 TO 190                   | 1.493E-05        | 1700 TO 1900                 | 3.479E-03        |
| 19 TO 21                     | 4.038E-05        | 190 TO 210                   | 2.285E-05        | 1900 TO 2100                 | 2.594E-03        |
| 21 TO 23                     | 4.979E-05        | 210 TO 230                   | 2.141E-05        | 2100 TO 2300                 | 1.860E-03        |
| 23 TO 25                     | 5.371E-05        | 230 TO 250                   | 2.214E-05        | 2300 TO 2500                 | 1.297E-03        |
| 25 TO 27                     | 5.758E-05        | 250 TO 270                   | 1.383E-05        | 2500 TO 2700                 | 9.403E-04        |
| 27 TO 29                     | 6.115E-05        | 270 TO 290                   | 1.059E-05        | 2700 TO 2900                 | 6.940E-04        |
| 29 TO 31                     | 8.197E-05        | 290 TO 310                   | 5.346E-06        | 2900 TO 3100                 | 2.388E-04        |
| AVERAGE TOTAL IWC            | .06790 GM/CU M   | IWC STANDARD DEVIATION       | .05945 GM/CU M   |                              |                  |

APPENDIX B

B2-5.1



meteorology research, inc. • 464 w. woodbury rd. • altadena, calif.

25 May 1975  
File 910 414 1493

Mailing address:  
Box 657, Altadena,  
Calif. 91001  
Phone: 213 791 1901

Dr. Robert Cunningham (LY)  
Air Force Cambridge Research Labs  
Laurence G. Hanscom Field  
Bedford, Massachusetts 01730

Dear Bob:

As discussed on 23 May, the Citation PMS measurements taken on the following dates will be processed using the following size-mass relationships.

April 25 1975

Run #1 at 18 k ft -7C spatial dendrites and snow aggregates

Density table as indicated in letter of 7 April 1975 for  
run #3 at -12C.

April 28 1975

Run #2 at 16 k ft -4C snow aggregates and spatial dendrites

Density table as indicated in letter of 7 April 1975 for  
run #3.

Run #1 at 11 k ft 3C melting snow

Density ratios of 1.0 for particles less than or equal to  
0.9 mm.

For particle sizes larger than 0.9 mm, the density ratios  
are based upon the following equivalent water diameter (d)  
vs measured size (L) relationship.

$$d \text{ (mm)} = 1.07 \text{ L (mm)}^{0.653}$$

$$\text{Density Ratio} = 1.22504 \text{ L (mm)}^{-1.041}$$

Citation Flight on 25 April 1975

Run #1 Spatial Dendrites and Snow

Citation Flight on 28 April 1975

Run #1 Wet Snow

Run #2 Spatial Dendrites and Snow

DENSITY TABLE FOR WET SNOW

| Channel No. | Size (mm) | Density Ratio |
|-------------|-----------|---------------|
| 1           | 0.2       | 1.0           |
| 2           | 0.4       | 1.0           |
| 3           | 0.6       | 1.0           |
| 4           | 0.8       | 1.0           |
| 5           | 1.0       | 1.22504       |
| 6           | 1.2       | 1.01327       |
| 7           | 1.4       | 0.863042      |
| 8           | 1.6       | 0.751039      |
| 9           | 1.8       | 0.664374      |
| 10          | 2.0       | 0.595359      |
| 11          | 2.2       | 0.539125      |
| 12          | 2.4       | 0.492438      |
| 13          | 2.6       | 0.453069      |
| 14          | 2.8       | 0.419430      |
| 15          | 3.0       | 0.390363      |

Approved

*R M Cunningham* Date *27 May 75*

All of the above constitutes technical input under the terms and conditions of contract DNA 001-75-C-0040. None of the above implies any changes in the scope, terms, conditions or price of the contract.

*fine*

Citation Flight on March 7, 1975

Run #1 - Bullet Rosettes

Run #2 - Bullet Rosettes

Run #3 - Spatial Dendrites

DENSITY TABLE FOR SPATIAL DENDRITES

| CPS<br>Size<br>( $\mu$ ) | Density<br>Ratio | PPS<br>Size<br>( $\mu$ ) | Density<br>Ratio |
|--------------------------|------------------|--------------------------|------------------|
| 20                       | 0.273            | 200                      | 0.0833           |
| 40                       | 0.237            | 400                      | 0.0530           |
| 60                       | 0.182            | 600                      | 0.0407           |
| 80                       | 0.151            | 800                      | 0.0338           |
| 100                      | 0.131            | 1000                     | 0.0292           |
| 120                      | 0.116            | 1200                     | 0.0259           |
| 140                      | 0.105            | 1400                     | 0.0235           |
| 160                      | 0.0963           | 1600                     | 0.0215           |
| 180                      | 0.0892           | 1800                     | 0.0199           |
| 200                      | 0.0833           | 2000                     | 0.0186           |
| 220                      | 0.0782           | 2200                     | 0.0175           |
| 240                      | 0.0739           | 2400                     | 0.0165           |
| 260                      | 0.0702           | 2600                     | 0.0157           |
| 280                      | 0.0669           | 2800                     | 0.0149           |
| 300                      | 0.0639           | 3000                     | 0.0143           |

Approved \_\_\_\_\_

Date \_\_\_\_\_

APPENDIX C

C2-5.1

| <u>BUF WORD<br/>NUMBER</u> | <u>PARAMETER</u>  |
|----------------------------|---|
| 1                          | 7777.   |
| 2                          | IDATE   |
| 3                          | ITIME   |
| 4                          | NSEC  |
| 5                          | TAS (m/sec)   |
| 6                          | PRES (mb)   |
| 7                          | ALT (km)  |
| 8                          | TEMP (°C)   |
| 9                          | ASP Water Content (gm/m <sup>3</sup> )                      |
| 10                         | CPS Water Content (gm/m <sup>3</sup> )                      |
| 11                         | PPS Water Content (gm/m <sup>3</sup> )                      |
| 12                         | ASP Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 13                         | CPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 14                         | PPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 15                         | ASP Total Counts  |
| 16                         | CPS Total Counts  |
| 17                         | PPS Total Counts  |
| 18                         | Latitude (Deg)  |
| 19                         | Longitude (Deg)   |
| 20                         | Not Used  |
| 21                         | ASP No. Density (No/m <sup>3</sup> )                        |
| 22                         | CPS No. Density (No/m <sup>3</sup> )                        |
| 23                         | PPS No. Density (No/m <sup>3</sup> )                        |
| 24                         | Total Water Content (gm/m <sup>3</sup> )                    |
| 25                         | Total Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> ) |
| 26                         | Total Number Density (No/m <sup>3</sup> )                   |

|         |   |
|---------|---|
| 27      | Largest particle size   |
| 28      | Average PPS particle size                                     |
| 29      | Not Used  |
| 30      | Not Used  |
| 31-75   | Number Density for size channels<br>1-45 (No/m <sup>3</sup> ) |
| 71-100  | Counts for size channels 1-45                                 |
| 121-165 | Water Content for size channels 1-45<br>(gm/m <sup>3</sup> )  |
| 166-210 | Melted equivalent diameter for size<br>channels 1-45 (μ)      |

SUPPLEMENT 2-6

Data Summary for Correlation Operation

28 April 1975

by

C. Cullian

S. Thomas

First issued as MRI 75R-1359, 28 August 1975

2-6.1

## TABLE OF CONTENTS

|                          | Page   |
|--------------------------|--------|
| 1. INTRODUCTION          | 2-6.3  |
| 2. MISSION DESCRIPTION   | 2-6.3  |
| 3. EQUIPMENT OPERATION   | 2-6.3  |
| 4. REDUCED PARTICLE DATA | 2-6.3  |
| 5. AFCRL DIGITAL TAPE    | 2-6.4  |
| APPENDIX A               | A2-6.1 |
| APPENDIX B               | B2-6.1 |
| APPENDIX C               | C2-6.1 |

## 1. INTRODUCTION

This document contains reduced cloud physics data acquired in support of the correlation operation on 28 April 1975. After careful review, the raw data were processed in accordance with the procedures described in Report Number MRI 75 R-1325.

## 2. MISSION DESCRIPTION

The Citation cloud physics research aircraft flew in support of a correlation operation on 28 April 1975. The Citation departed from Wallops Flight Center at 1810 Z and landed at 1933 Z. Sampling runs were conducted at FL 110 from 1906 Z to 1913 Z, and FL 160 from 1920 Z to 1924 Z.

During the first pass at FL 110 the temperature was  $4^{\circ}\text{C}$  and cloud cover was not uniform. The airspeed varied from 122 to 126 KIAS.

During the final pass at FL 160 the temperature was  $-4^{\circ}\text{C}$  and the airspeed varied from 118 to 122 KIAS.

## 3. EQUIPMENT OPERATION

All sensors were functional and collected data.

## 4. REDUCED PARTICLE DATA

Reduced particle data from the Citation flight are shown in Appendix A.

The data presented are pass averages of the number density for melted equivalent diameters corresponding to each size channel of the spectrometer probes. Additionally the pass averages of the water content for these size channels are presented.

The total water content was computed using the density table shown in Appendix B. The letter confirming the verbal agreement on the crystal type and the corresponding size-mass relationships to be used in processing the data is also enclosed in Appendix B.

5. AFCRL DIGITAL TAPE

The data tape accompanying this report is in the AFCRL format, as shown in Appendix C, and provides one-second values of the data taken during each of the sampling runs.

APPENDIX A

A2-6.1

A2-6.2

CITATION DATA  
4/28/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19- 6- 1Z STOP TIME 19-12-51Z  
START POSITION 37-42-0N, 75- 8-1W END POSITION 37-51.9N, 75-18.0W  
TEMPERATURE 3.8 DEG C ALTITUDE 3362 MET TAS 73.7 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M3-MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NC/M3-MIC) |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|
| 3.0 TC 5.0                      | 3.0207E+05                       | 30.0 TO 50.0                    | 8.9111E+03                       | 300.0 TO 500.0                  | 1.0943E+01                       |
| 5.0 TO 7.0                      | 1.9817E+05                       | 50.0 TO 70.0                    | 3.8675E+03                       | 500.0 TO 700.0                  | 6.6604E+00                       |
| 7.0 TC 9.0                      | 2.3575E+04                       | 70.0 TO 90.0                    | 8.5493E+02                       | 700.0 TO 935.0                  | 3.6483E+00                       |
| 9.0 TO 11.0                     | 1.1750E+04                       | 90.0 TO 110.0                   | 4.0735E+02                       | 935.0 TO 1137.6                 | 2.6916E+00                       |
| 11.0 TC 13.0                    | 9.0720E+03                       | 110.0 TO 130.0                  | 2.2442E+02                       | 1137.6 TO 1269.1                | 2.4662E+00                       |
| 13.0 TO 15.0                    | 8.9271E+03                       | 130.0 TO 150.0                  | 1.0126E+02                       | 1269.1 TO 1393.6                | 1.4705E+00                       |
| 15.0 TC 17.0                    | 7.1918E+03                       | 150.0 TO 170.0                  | 3.2417E+01                       | 1393.6 TO 1512.5                | 1.0016E+00                       |
| 17.0 TO 19.0                    | 7.7346E+03                       | 170.0 TO 190.0                  | 2.4559E+01                       | 1512.5 TO 1626.6                | 6.1833E-01                       |
| 19.0 TC 21.0                    | 5.7722E+03                       | 190.0 TO 210.0                  | 2.2962E+01                       | 1626.6 TO 1736.5                | 3.499 E-01                       |
| 21.0 TC 23.0                    | 6.1586E+03                       | 210.0 TO 230.0                  | 1.2731E+01                       | 1736.5 TO 1842.9                | 2.1312E-01                       |
| 23.0 TC 25.0                    | 5.2192E+03                       | 230.0 TO 250.0                  | 5.2878E+00                       | 1842.9 TO 1946.1                | 1.4879E-01                       |
| 25.0 TC 27.0                    | 4.9378E+03                       | 250.0 TO 270.0                  | 6.6539E+00                       | 1946.1 TO 2046.4                | 8.3513E-02                       |
| 27.0 TC 29.0                    | 4.9625E+03                       | 270.0 TO 290.0                  | 6.4659E+00                       | 2046.4 TO 2144.2                | 5.252 E-02                       |
| 29.0 TO 31.0                    | 5.0931E+03                       | 290.0 TO 310.0                  | 3.2025E+00                       | 2144.2 TO 2240.8                | 3.1515E-02                       |

CITATION DATA  
4/28/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-6-12 STOP TIME 19-12-51Z  
START POSITION 37-42.0N, 75-8.1W END POSITION 37-51.9N, 75-18.0W  
TEMPERATURE 3.8 DEG C ALTITUDE 3362 MET TAS 73.7 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M)       | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------------|------------------------------|------------------|
| 3 TO 5                       | 2.024E-05        | 30 TO 50                     | 5.972E-03              | 300 TO 500                   | 7.332E-02        |
| 5 TO 7                       | 4.482E-05        | 50 TO 70                     | 8.748E-03              | 500 TO 700                   | 1.507E-01        |
| 7 TO 9                       | 1.264E-05        | 70 TO 90                     | 4.584E-03              | 700 TO 900                   | 2.298E-01        |
| 9 TO 11                      | 1.231E-05        | 90 TO 110                    | 4.226E-03              | 900 TO 1100                  | 3.499E-01        |
| 11 TO 13                     | 1.642E-05        | 110 TO 130                   | 4.061E-03              | 1100 TO 1300                 | 2.972E-01        |
| 13 TO 15                     | 2.565E-05        | 130 TO 150                   | 2.913E-03              | 1300 TO 1500                 | 2.271E-01        |
| 15 TO 17                     | 3.085E-05        | 150 TO 170                   | 1.350E-03              | 1500 TO 1700                 | 1.917E-01        |
| 17 TO 19                     | 4.724E-05        | 170 TO 190                   | 1.500E-03              | 1700 TO 1900                 | 1.431E-01        |
| 19 TO 21                     | 4.836E-05        | 190 TO 210                   | 1.924E-03              | 1900 TO 2100                 | 9.594E-02        |
| 21 TO 23                     | 6.867E-05        | 210 TO 230                   | 1.420E-03              | 2100 TO 2300                 | 6.813E-02        |
| 23 TO 25                     | 7.558E-05        | 230 TO 250                   | 7.655E-04              | 2300 TO 2500                 | 5.473E-02        |
| 25 TO 27                     | 9.666E-05        | 250 TO 270                   | 1.225E-03              | 2500 TO 2700                 | 3.494E-02        |
| 27 TO 29                     | 1.141E-04        | 270 TO 290                   | 1.487E-03              | 2700 TO 2900                 | 2.476E-02        |
| 29 TO 31                     | 1.440E-04        | 290 TO 310                   | 9.055E-04              | 2900 TO 3100                 | 1.680E-02        |
| AVERAGE TOTAL IWC            | 1.0911E-01       |                              | IWC STANDARD DEVIATION |                              | .93540 GM/CU M   |

CITATION DATA  
4/28/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-19-31Z STOP TIME 19-24-12  
START POSITION 37-49.0N, 75-14.6W END POSITION 37-36.1N, 75-1.5W  
TEMPERATURE -3.3 DEG C ALTITUDE 4885 MET TAS 80.8 M/SEC

AVERAGE NUMBER DENSITY VALUES FOR EACH SIZE RANGE

| MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) | MELTED<br>DIAMETER<br>(MICRONS) | NUMBER<br>DENSITY<br>(NO/M <sup>3</sup> -MIC) |
|---------------------------------|---|---------------------------------|---|---------------------------------|---|
| 2.9 TO 4.8                      | 7.0924E+06                                    | 18.9 TO 29.4                    | 8.6214E+03                                    | 118.8 TO 178.3                  | 4.7933E+00                                    |
| 4.8 TO 6.8                      | 1.8398E+07                                    | 29.4 TO 38.3                    | 4.8074E+03                                    | 178.3 TO 232.5                  | 3.1639E+00                                    |
| 6.8 TO 8.7                      | 1.1819E+07                                    | 38.3 TO 46.7                    | 2.5050E+03                                    | 232.5 TO 283.3                  | 3.1658E+00                                    |
| 8.7 TO 10.6                     | 3.4302E+06                                    | 46.7 TO 54.7                    | 2.4818E+03                                    | 283.3 TO 331.5                  | 2.9039E+00                                    |
| 10.6 TO 12.5                    | 7.9979E+05                                    | 54.7 TO 62.3                    | 1.5159E+03                                    | 331.5 TO 378.0                  | 2.3828E+00                                    |
| 12.5 TO 14.5                    | 3.2010E+05                                    | 62.3 TO 69.7                    | 8.0768E+02                                    | 378.0 TO 423.0                  | 1.5671E+00                                    |
| 14.5 TO 16.4                    | 2.9634E+04                                    | 69.7 TO 76.9                    | 4.3619E+02                                    | 423.0 TO 466.3                  | 1.3632E+00                                    |
| 16.4 TO 17.9                    | 1.7952E+04                                    | 76.9 TO 83.9                    | 2.4863E+02                                    | 466.3 TO 516.8                  | 7.5274E-01                                    |
| 17.9 TO 19.1                    | 1.3024E+04                                    | 83.9 TO 90.7                    | 2.2081E+02                                    | 516.8 TO 550.5                  | 4.9342E-01                                    |
| 19.1 TO 20.3                    | 1.3721E+04                                    | 90.7 TO 97.4                    | 1.8318E+02                                    | 550.5 TO 591.1                  | 3.0749E-01                                    |
| 20.3 TO 21.5                    | 1.0213E+04                                    | 97.4 TO 104.0                   | 1.1467E+02                                    | 591.1 TO 631.0                  | 2.2215E-01                                    |
| 21.5 TO 22.6                    | 9.0997E+03                                    | 104.0 TO 110.5                  | 9.7738E+01                                    | 631.0 TO 670.0                  | 1.5168E-01                                    |
| 22.6 TO 23.7                    | 7.9605E+03                                    | 110.5 TO 116.8                  | 7.4809E+01                                    | 670.0 TO 708.6                  | 7.5328E-02                                    |
| 23.7 TO 24.8                    | 1.1937E+04                                    | 116.8 TO 123.1                  | 4.5347E+01                                    | 708.6 TO 747.8                  | 7.1076E-02                                    |

CITATION DATA  
4/28/75

AVERAGE VALUES FOR SAMPLE RUN

START TIME 19-19-31Z STOP TIME 19-24-12  
START POSITION 37-49.0N, 75-14.6W END POSITION 37-36.1N, 75-1.5W  
TEMPERATURE -3.3 DEG C ALTITUDE 4889 MET TAS 80.8 M/SEC

AVERAGE WATER CONTENT VALUES FOR EACH SIZE RANGE

| CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) | CHANNEL<br>SIZE<br>(MICRONS) | IWC<br>(GM/CU M) |
|------------------------------|------------------|------------------------------|------------------|------------------------------|------------------|
| 3 TO 5                       | 4.122E-04        | 30 TO 50                     | 7.200E-04        | 300 TO 500                   | 5.067E-04        |
| 5 TO 7                       | 3.609E-03        | 50 TO 70                     | 8.830E-04        | 500 TO 700                   | 7.894E-04        |
| 7 TO 9                       | 5.495E-03        | 70 TO 90                     | 1.151E-03        | 700 TO 900                   | 1.457E-03        |
| 9 TO 11                      | 3.115E-03        | 90 TO 110                    | 1.355E-03        | 900 TO 1100                  | 2.066E-03        |
| 11 TO 13                     | 1.255E-03        | 110 TO 130                   | 1.214E-03        | 1100 TO 1300                 | 2.598E-03        |
| 13 TO 15                     | 7.976E-04        | 130 TO 150                   | 5.025E-04        | 1300 TO 1500                 | 2.377E-03        |
| 15 TO 17                     | 1.102E-04        | 150 TO 170                   | 6.476E-04        | 1500 TO 1700                 | 2.737E-03        |
| 17 TO 19                     | 7.813E-05        | 170 TO 190                   | 6.651E-04        | 1700 TO 1900                 | 1.944E-03        |
| 19 TO 21                     | 5.044E-05        | 190 TO 210                   | 5.260E-04        | 1900 TO 2100                 | 1.603E-03        |
| 21 TO 23                     | 6.591E-05        | 210 TO 230                   | 5.328E-04        | 2100 TO 2300                 | 1.216E-03        |
| 23 TO 25                     | 5.678E-05        | 230 TO 250                   | 4.041E-04        | 2300 TO 2500                 | 1.059E-03        |
| 25 TO 27                     | 5.740E-05        | 250 TO 270                   | 4.089E-04        | 2500 TO 2700                 | 8.547E-04        |
| 27 TO 29                     | 5.748E-05        | 270 TO 290                   | 3.648E-04        | 2700 TO 2900                 | 4.975E-04        |
| 29 TO 31                     | 5.813E-05        | 290 TO 310                   | 2.569E-04        | 2900 TO 3100                 | 5.628E-04        |

MEAN IWC .04514 GM/CU M IWC STANDARD DEVIATION .03336 GM/CU M

APPENDIX B

B2-6.1



meteorology research, inc. • 464 w. woodbury rd. • altadena, calif.

25 May 1975  
File 910 414 1493

Mailing address:  
Box 657 Altadena,  
Calif. 91001  
Phone: 213 791 1401

Dr. Robert Cunningham (LY)  
Air Force Cambridge Research Labs  
Laurence G. Hanscom Field  
Bedford, Massachusetts 01730

Dear Bob:

As discussed on 23 May, the Citation PMS measurements taken on the following dates will be processed using the following size-mass relationships.

April 25 1975

Run #1 at 18 k ft -7C spatial dendrites and snow aggregates

Density table as indicated in letter of 7 April 1975 for  
run #3 at -12C.

April 28 1975

Run #2 at 16 k ft -4C snow aggregates and spatial dendrites

Density table as indicated in letter of 7 April 1975 for  
run #3.

Run #1 at 11 k ft 3C melting snow

Density ratios of 1.0 for particles less than or equal to  
0.9 mm.

For particle sizes larger than 0.9 mm, the density ratios  
are based upon the following equivalent water diameter ( $d$ )  
vs measured size ( $L$ ) relationship.

$$d \text{ (mm)} = 1.07 L \text{ (mm)}^{0.613}$$

$$\text{Density Ratio} = 1.22504 L \text{ (mm)}^{-1.04}$$

Citation Flight on 25 April 1975

Run #1 Spatial Dendrites and Snow

Citation Flight on 28 April 1975

Run #1 Wet Snow

Run #2 Spatial Dendrites and Snow

DENSITY TABLE FOR WET SNOW

| Channel No. | Size (mm) | Density Ratio |
|-------------|-----------|---------------|
| 1           | 0.2       | 1.0           |
| 2           | 0.4       | 1.0           |
| 3           | 0.6       | 1.0           |
| 4           | 0.8       | 1.0           |
| 5           | 1.0       | 1.22504       |
| 6           | 1.2       | 1.01327       |
| 7           | 1.4       | 0.863042      |
| 8           | 1.6       | 0.751039      |
| 9           | 1.8       | 0.664374      |
| 10          | 2.0       | 0.595359      |
| 11          | 2.2       | 0.539125      |
| 12          | 2.4       | 0.492438      |
| 13          | 2.6       | 0.453069      |
| 14          | 2.8       | 0.419430      |
| 15          | 3.0       | 0.390363      |

Approved

*R M Cunningham*

Date

*27 May 75*

All of the above constitutes technical input under the terms and conditions of contract DNA 001-75-C-0040. None of the above implies any changes in the scope, terms, conditions or price of the contract.

*fmC*

Citation Flight on March 7, 1975

Run #1 - Bullet Rosettes

Run #2 - Bullet Rosettes

Run #3 - Spatial Dendrites

DENSITY TABLE FOR SPATIAL DENDRITES

| CPS<br>Size<br>( $\mu$ ) | Density<br>Ratio | PPS<br>Size<br>( $\mu$ ) | Density<br>Ratio |
|--------------------------|------------------|--------------------------|------------------|
| 20                       | 0.273            | 200                      | 0.0833           |
| 40                       | 0.237            | 400                      | 0.0530           |
| 60                       | 0.182            | 600                      | 0.0407           |
| 80                       | 0.151            | 800                      | 0.0338           |
| 100                      | 0.131            | 1000                     | 0.0292           |
| 120                      | 0.116            | 1200                     | 0.0259           |
| 140                      | 0.105            | 1400                     | 0.0235           |
| 160                      | 0.0963           | 1600                     | 0.0215           |
| 180                      | 0.0892           | 1800                     | 0.0199           |
| 200                      | 0.0833           | 2000                     | 0.0186           |
| 220                      | 0.0782           | 2200                     | 0.0175           |
| 240                      | 0.0739           | 2400                     | 0.0165           |
| 260                      | 0.0702           | 2600                     | 0.0157           |
| 280                      | 0.0669           | 2800                     | 0.0149           |
| 300                      | 0.0639           | 3000                     | 0.0143           |

Approved \_\_\_\_\_

Date \_\_\_\_\_

APPENDIX C

C2-6.1

| <u>BUF WORD<br/>NUMBER</u> | <u>PARAMETER</u>  |
|----------------------------|---|
| 1                          | 7777.   |
| 2                          | IDATE   |
| 3                          | ITIME   |
| 4                          | NSEC  |
| 5                          | TAS (m/sec)   |
| 6                          | PRES (mb)   |
| 7                          | ALT (km)  |
| 8                          | TEMP (°C)   |
| 9                          | ASP Water Content (gm/m <sup>3</sup> )                      |
| 10                         | CPS Water Content (gm/m <sup>3</sup> )                      |
| 11                         | PPS Water Content (gm/m <sup>3</sup> )                      |
| 12                         | ASP Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 13                         | CPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 14                         | PPS Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> )   |
| 15                         | ASP Total Counts  |
| 16                         | CPS Total Counts  |
| 17                         | PPS Total Counts  |
| 18                         | Latitude (Deg)  |
| 19                         | Longitude (Deg)   |
| 20                         | Not Used  |
| 21                         | ASP No. Density (No/m <sup>3</sup> )                        |
| 22                         | CPS No. Density (No/m <sup>3</sup> )                        |
| 23                         | PPS No. Density (No/m <sup>3</sup> )                        |
| 24                         | Total Water Content (gm/m <sup>3</sup> )                    |
| 25                         | Total Radar Reflectivity (mm <sup>6</sup> /m <sup>3</sup> ) |
| 26                         | Total Number Density (No/m <sup>3</sup> )                   |

|         |  |
|---------|--|
| 27      | Largest particle size  |
| 28      | Average PPS particle size                                      |
| 29      | Not Used   |
| 30      | Not Used   |
| 31-75   | Number Density for size channels<br>1-45 (No/m <sup>3</sup> )  |
| 71-100  | Counts for size channels 1-45                                  |
| 121-165 | Water Content for size channels 1-45<br>(gm/m <sup>3</sup> )   |
| 166-210 | Melted equivalent diameter for size<br>channels 1-45 ( $\mu$ ) |

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